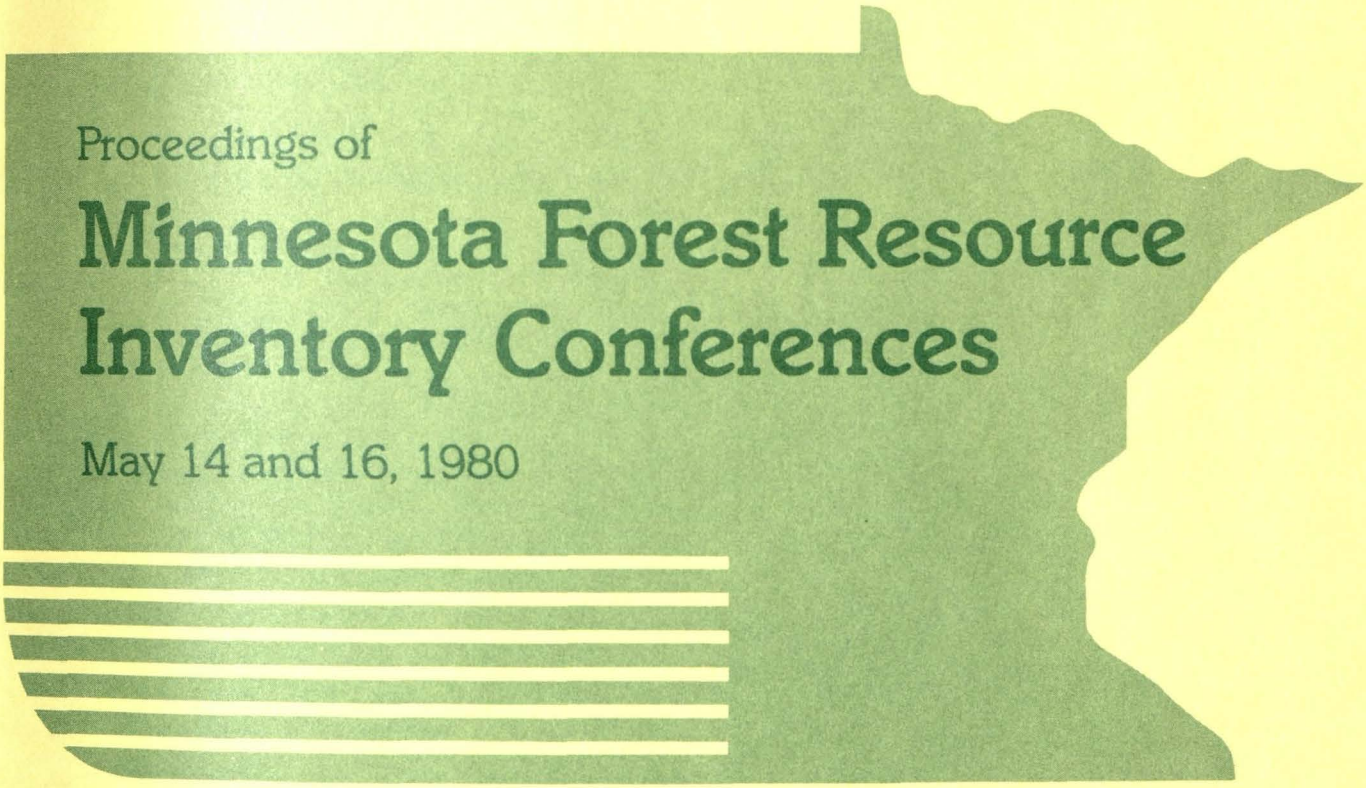
USDA FOREST SERVICE
GENERAL TECHNICAL REPORT **NC-64**



Proceedings of

Minnesota Forest Resource Inventory Conferences

May 14 and 16, 1980

North Central Forest Experiment Station
Forest Service, U.S. Department of Agriculture

North Central Forest Experiment Station

Forest Service - U.S. Department of Agriculture

1992 Folwell Avenue

St. Paul, Minnesota 55108

Manuscript approved for publication June 20, 1980

1981

FOREWORD

The Minnesota Forest Resource Inventory Conferences were held in Grand Rapids on May 14, 1980 and in White Bear Lake on May 16, 1980. The Conferences were conceived and sponsored jointly by the North Central Forest Experiment Station; Minnesota Department of Natural Resources, Division of Forestry; and the University of Minnesota, College of Forestry as a means of promoting useful dialogue within and beyond the Minnesota forestry community.

The purpose of the conferences was to inform the interested public of the background and results of the 1977 inventory of Minnesota's forest resources, and to make them aware of ways inventory information is utilized by the many kinds of users. To do this, we assembled speakers who were most closely associated with conducting the inventory, along with representatives of the key groups that make use of inventory data--forest industry, regional planning organizations, National Forests, State departments of natural resources, universities, environmental groups, and consultants. Their comments are summarized in the papers in this Proceedings.

Papers from authors outside the North Central Forest Experiment Station are printed just as received; their content and presentation are the responsibility of the authors themselves.

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OVERVIEW OF INVENTORY RESPONSIBILITIES

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Inventories of the Nation's forests date back to the early 1930's. Enabling legislation for the early inventories was the Mc Sweeney-Mc Nary Forest Research Act of 1928. For forty years this act provided authorization for our forest inventories. In 1974 new legislation amended the Mc Sweeney-Mc Nary Act and provided more comprehensive guidelines for National resource inventories. This new legislation was the Forest and Rangeland Renewable Resources Planning Act (R.P.A). It directed the Secretary of Agriculture to prepare a renewable resources assessment in 1975, and to update the assessment in 1980 and each 10th year thereafter.

The 1980 National assessment will soon be released. It provides four basic kinds of information: (1) a description of the resource base, (2) projected trends in supplies and demand, (3) economic, social and environmental impacts of these trends; and (4) opportunities to improve the trends that may have adverse impacts.

Timber resource information used in these National assessments is gathered by resources evaluation projects of the U. S. D. A. Forest Service (formerly called "forest survey" projects). They are located at six forest experiment stations across the country--Broomall, Pennsylvania; Asheville, North Carolina; New Orleans, Louisiana; Ogden, Utah, Portland, Oregon; and St. Paul, Minnesota.

The resources evaluation project for the North Central region is located at the North Central Forest Experiment Station in St. Paul, Minnesota and is responsible for inventorying resources in Minnesota, Wisconsin, Michigan, Iowa, Indiana, Illinois, Missouri, North Dakota, eastern South Dakota, Nebraska, and Kansas. The North Central Region encompasses the third largest land area in the Nation and has the fourth largest commercial forest land base. Although its softwood volume is small, its hardwood volume is second only to that found in the Northeastern region.

The fourth inventory of Minnesota was the most intensive Statewide inventory ever conducted in the United States. The Minnesota State Legislature provided the Minnesota Department of Natural Resources (DNR) with funds sufficient to triple the sample over that of the standard inventory. This was done because the DNR and other interested parties wanted more accurate county estimates than the standard inventory, authorized by Congress, would yield. The standard inventory would have provided reliable resource statistics, but only at the State level and for some of the larger, more heavily forested counties.

This intensified inventory of the State's forest land significantly reduced the sampling error of the resulting statistics. For example, the sampling error for the estimate of commercial forest land for 10,000 acres in the Northern Pine Unit was reduced from ± 30 percent (for a standard inventory) to ± 17.3 percent (for the intensified sample). If we assume that the 10,000 acres support 11 cords per acre of growing-stock trees (the average for this Unit) the sampling error for total volume is ± 26.5 percent for the intensified inventory. This is much less than the sampling error of ± 53.5 percent that would have resulted from a standard inventory.

The Minnesota inventory was a cooperative effort. Most of the aerial photos were provided by the Minnesota DNR. Other photos were supplied by county land commissioners, the two National Forests, and the Bureau of Indian Affairs. Agricultural Stabilization and Conservation Service photography was also used. The two National Forests provided resource information for their land. DNR foresters contacted wood-using plants in the State to determine the kinds and amounts of products coming from Minnesota's forests and also established two thirds of the field plots throughout the State.

North Central foresters established one third of the field plots required for the inventory and conducted timber utilization studies on current logging operations. These utilization studies provided the information necessary to link production figures provided by forest industry back to the amount of standing timber harvested to provide those products. Fieldwork began in July 1974 and was completed in March of 1978. Nearly 115 staff years went into the fieldwork for this inventory.

Another cooperator, the Minnesota State Planning Agency, developed a computerized vegetation cover type map of the State. North Central Station photo-interpreters delineated the various land classes on orthophoto maps, which were then processed into the type map by the State Planning Agency. As far as I know the resulting vegetation map is another first-of-a-kind.

Data processing was done at the North Central Station. Field plot sheets were sent to St. Paul where they were key-punched and edited. When an inventory unit was complete, area, volume, and growth statistics were computed and tabled. The Station has more than 7000 Minnesota statistical tables stored on microfilm--slightly more than 80 tables per county.

The information produced from the inventory is used by various groups for various purposes. At the North Central Station, resource analysts use the information to describe and highlight various aspects of the timber resource, point out areas of concern, and suggest possible alternatives.

Seventeen reports are planned by the Station to present Minnesota's forest resources:

Research Notes:

Forest area in Minnesota

Timber volume in Minnesota

Minnesota land ownership trends, 1962-1977

Biomass in Minnesota's forests

Resource Bulletins:

Forest statistics for Minnesota, 1977

Timber resource of Minnesota's Aspen-Birch Unit

Timber resource of Minnesota's Northern Pine Unit

Timber resource of Minnesota's Central Hardwood Unit

Timber resource of Minnesota's Prairie Unit

The fourth Minnesota forest inventory: area

The fourth Minnesota forest inventory:
volume, growth, removals, and projections

Predicted yields from selected cutting prescriptions
in northern Minnesota

Treatment opportunities for current Minnesota forest conditions

Operability of Minnesota's commercial forest lands

Fuelwood production in rural Minnesota, 1975

Minnesota logging utilization factors,
1975-1976-development, use, implications

Biomass in Minnesota's forests

MINNESOTA FOREST INVENTORY PROCEDURES

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The inventory of Minnesota utilized a two-stage sampling technique. This approach uses aerial photography in combination with data obtained from on-the-ground measurements.

Aerial Photograph Sampling

The first step in the aerial photo sample procedure is to assemble a township mosaic of conventional aerial photographs. Next, a grid to match the township is placed over the photos. The grid is a transparent acetate sheet covering an area of 6 square miles in the scale of the photos used and is designed to locate 121 circular points, with each point representing 1-acre. This grid provides 100 percent area control when every township is counted. All points on the grid are then classified as to their land-use. These classified points give us a preliminary estimate of forest and nonforest land in a county. In Minnesota 72,700 points were classed as forest, 2,000 as questionable, 4,500 as unproductive forest land and 200,000 as nonforest or water.

Next, a photograph is taken of the township mosaic with the grid in place. This photo provides us with a record of all sample points and is insurance in the event we should ever lose track of the aerial photo used in the ground sample.

The township mosaic is then dissassembled and all forest points on the photos are stereoscopically interpreted. Each of the 72, 700 forest points in Minnesota were given 1 of 12 forest cover type classes.

The last step in the photo work phase is to systematically select a subsample of these photo points for examination on the ground to correct the preliminary area estimate for classification errors and for actual land use change since the photos were taken. In Minnesota, 9,800 points classed as forest, 4,500 points classed as unproductive forest, and 2,000 points classed as questionable were examined on the ground.

Field Data Collection

Of the 16,300 plots examined on the ground for the Minnesota survey, 8,547 were classed as commercial forest land. The ground sample phase of the inventory concentrated primarily on commercial forest land. However, limited ground data are collected on other ground land use classifications--unproductive forest land, productive reserved forest land, and nonforest land with trees such as wooded strips, and wooded pasture.

All the counties within a particular unit have similar tree species, forest types, etc. (figure 1).

The commercial forest land plots by Inventory Unit were as follows:

	Number of plots
Aspen-Birch Unit	3,093
Northern Pine Unit	3,718
Central Hardwood Unit	1,362
Prairie Unit	374
Total	8,547

Tree measurements were made on the 8,547 ground plots plus the data from the National Forests are the basis for estimates of timber volume, growth, mortality, number of trees, and other forest classifications. Each ground plot represents about 1,400 acres of commercial forest land.

The first step in locating the forest sample location is to draw a straight reference line between two features visible on the photograph and eaily located on the ground. A good example of such a feature is a straight road section. This reference line with azimuth is recorded on the back of the aerial photograph.

Next, a starting point is selected. It has to be a landmark readily identifiable on the ground and on the photograph and as close to the sample location as possible. Landmarks are selected that can be easily identified later for remeasurement purposes, for example, a prominent tree along a road.

Using the reference line and a line from the starting point to the ground plot on the aerial photograph, an azimuth and distance are computed from the starting point to the ground plot location. Then a course is run from starting point to plot center using compass and 100-foot tape.

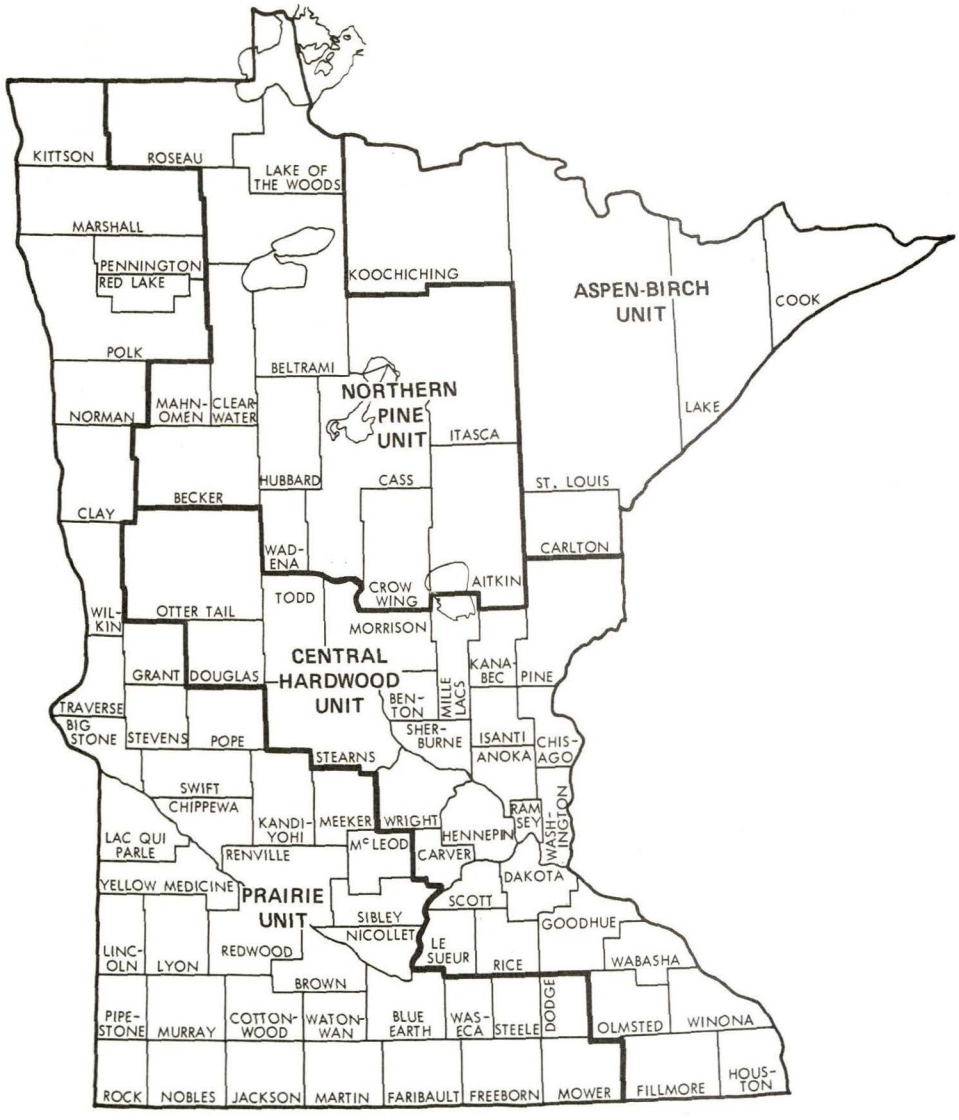

Figure 1. Location of forest inventory units, Minnesota, 1977

Once at the plot, the crew checks to make sure the photograph location agrees with the ground location. All our forest plots are considered permanent and great care is taken to locate, witness, and establish the plot so it can be remeasured later.

Our plots are sampled using a 10-point cluster design. This grid pattern of sample points is designed to obtain a uniform distribution of points over an area of approximately one-acre (fig. 2). Distance from point to point is 70 feet. Point one always determines land class. If point one is forest land and any of the remaining points fall on nonforest land, a substitute point is located on commercial forest land.

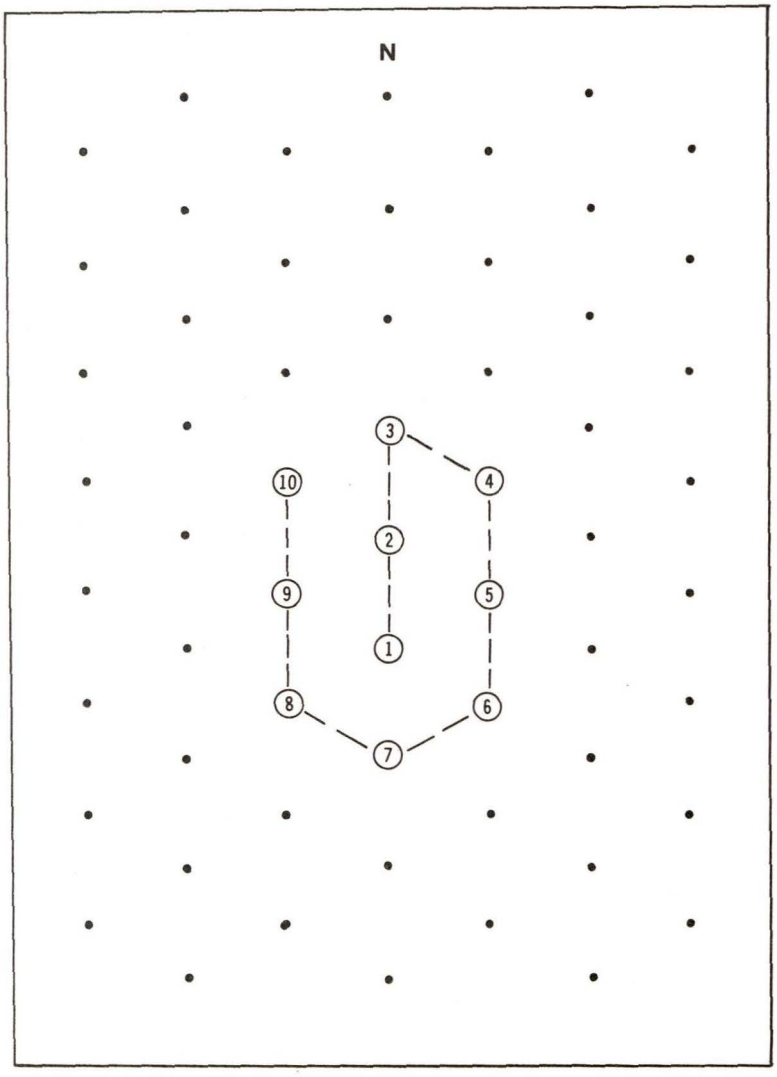

Figure 2. Ten-Point cluster design layout.
Distance from point to point is 70 feet.

At each plot point a 37.5 basal area factor, variable radius plot is established for all live trees 5.0 inches d.b.h. and larger that fall within the limiting distance. Trees are determined to be in or out of the tally depending on their d.b.h. and distance from the point center. For example, the limiting distance for a tree with a d.b.h. of 14.6 inches is 20.7 feet. A glass prism is used to determine which trees should be tallied, although the distance from point center to borderline trees is measured by tape.

Sapling-size trees (1.0 to 5.0 inches d.b.h.) are tallied on a fixed plot at each point (6.8 foot radius). Information on species, diameter, and tree class are recorded on these trees. Seedlings can also be recorded if the required number of saplings are not on the plot.

A tally of stumps cut within the last 3 years on a fixed radius plot (16.6 feet) is also made at each point. From this data, estimates can be computed of timber volume removed.

Up to 24 separate items can be recorded on our field plot sheets for each individual tree. Items recorded for a tree fall into one of three main groups: tree identification, tree measurement, and tree classification.

Each of the tally trees is identified by azimuth and distance from point center. Point number, tree number, tree history (live, dead, stump), and species were also recorded.

A permanent mark is placed on each tally tree at d.b.h. and at the base. Individual tree species is also recorded; in Minnesota 43 separate commercial tree species were recorded.

Tree measurements and observations are used to compute volume, growth, and quality. They include tree diameter, merchantable tree heights, and log grade.

Precise measurements and classifications are essential to keep field technique errors to a minimum because these errors will be expanded several hundred times during the data processing.

Tree diameter at breast height is a critical measurement and must be properly and accurately determined. It is used to determine if trees are in or out of the tally, and it is remeasured on subsequent surveys to determine growth. Diameter breast high is defined as tree diameter outside the bark at 4.5 feet above the ground.

Merchantable bole length of all growing-stock trees 5.0 inches d.b.h. and larger is determined as the distance between the top of a 1-footstump and a 4.0 inch top diameter outside bark, or the point at which the central stem is terminated by branches or rot. Cull is recorded for sections of trees that have forks, excessive limbs, sweep, crook or rot.

Saw log length is recorded for trees 9 inches d.b.h. and larger for softwoods and 11 inches d.b.h. and larger for hardwoods. It is measured from a 1-foot stump to the point on the bole above which no merchantable saw log can be produced because of excessive limbs or other defects, or to a minimum top diameter outside bark of 7 inches for softwoods and 9 inches outside bark for hardwood. To qualify as a sawtimber tree it must contain at least one 12 foot log or two 8 foot or longer logs; meet minimum saw log grade specifications; and contain 33 percent or more of the gross board foot volume in sound material.

The first saw log in each live sawtimber tree is log-graded. Log grade is a classification of logs based on external characteristics as indicators of quality and value.

The items listed below are recorded for all live trees of commercial species that are 5 inches d.b.h. or larger. These characteristics provide the basis for systematically grouping trees into classes that reflect their vigor and suitability for timber products.

Surface defects provide a measure of the number and size of limbs, knots, and external flaws that affect lumber and veneer quality.
Internal defects, sweep and crook are items that give estimates of tree's volume lost because of these defects.
Relative bole length, crown ratio, and crown class supply estimates of crown vigor and crown position.
Damage or pathogen activity furnish estimates of tree volume lost to these causes.

From the tree classification items listed above, tree classes of live trees are determined. Desirable and acceptable tree classes have traditionally been grouped together and called growing-stock or merchantable trees. Rough and rotten tree classes are grouped together and called cull or nonmerchantable trees.

The following Information is recorded at each ground location to describe the stand in which the plot falls:

Ownership class
Stand origin
Site class
Site index
Physiographic class
Stand age
Seed source
Forest type
Stand-size class
Aspect-position-slope
Basal area per acre
Stand history
Stand area
Distance to water and road
Conifer understory

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Vasilevsky, A. 1974. Photo Sampling Instructions for the Fourth Minnesota Forest Survey, USDA Forest Service, North Central Forest Experiment Station, St. Paul, Minnesota.

LAKE STATES' RESOURCE TRENDS

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Demand for forest resources is often exerted across broad regions, with little regard for political boundaries. For example, loggers, campers, hunters, and other forest users in Minnesota, Wisconsin, and Michigan frequently look beyond the boundaries of their home State to the Lake States Region to satisfy their demand for timber and nontimber forest resources. The purpose of this paper is to examine the forest resources of the three Lake States and to compare them to the forest resources of other areas of the Country. By presenting the statistics and comparisons in one package a complete picture can be obtained of the Lake States' forest resources and the Region's place in the United States forest picture.

State-wide forest inventories provide the basic data needed to assess a State's forest resources. However, it is often difficult to compare statistics from different States or combine data from several States due to different inventory dates. The assessment document produced in compliance with the Forest and Rangeland Renewable Resources Planning Act of 1974 (P.L. 93-378) is the one source of statistics for all States in a common year. In the assessment just being completed, the most recent forest inventory data for each state was updated to 1977. Preliminary statistics from the update are the basis for this paper.1/

Area

In 1977, forest land in the United States covered 738.5 million acres which is one-third of the Nation's total land area. This amounts to 3.5 acres of forest land per person in the United States. Forests are not distributed evenly across the Country, but rather are concentrated in the South, Pacific Coast, and Rocky Mountain Regions (fig. 1). The Lake States Region contains 9 percent of the Nation's land area and only 7 percent of the forest land area.

1/ USDA Forest Service. 1978. Forest Statistics of the United States, 1977. Review draft. 133 p. Minnesota statistics published in the review draft were updated from the 1962 forest inventory. The final document will contain the new 1977 Minnesota forest inventory data. Lake States statistics used in this paper were adjusted for the new Minnesota forest inventory data.

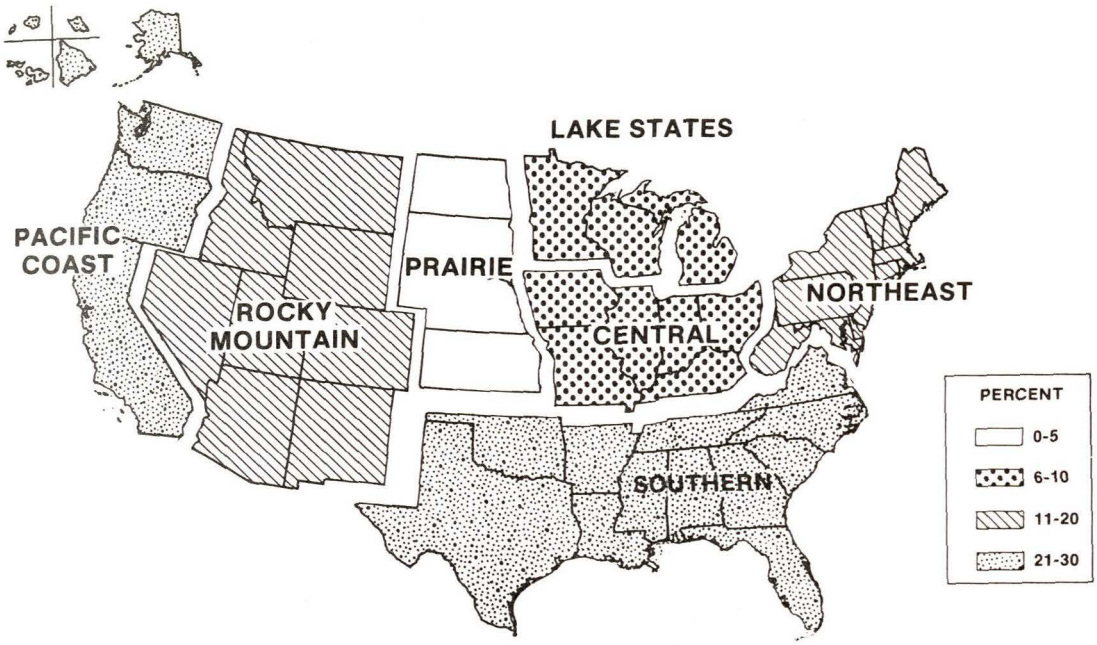

Figure 1. Distribution of the Nation's forest land among regions, 1977

Forest land is divided into three land-use categories: commercial, unproductive, and productive-reserved. Unproductive and productive-reserved forest land are often grouped together and called noncommercial forest land. During forest inventories efforts are concentrated on gathering data on commercial forest land because it is the portion of the forest area capable of producing crops of wood and available for timber utilization. In most regions, commerial forest land accounts for a majority of the forest area:

Region	Forest land	Commercial forest land	Noncommercial forest land
		(Million acres)	
Pacific Coast	214.5	70.8	142.7
Rocky Mountain	136.4	56.5	79.9
South	207.1	188.4	18.7
Northeast	84.3	79.2	5.1
Central	40.8	39.6	1.2
Prairie	4.5	3.8	0.7
Lake States	50.9	47.0	3.9
All Regions	738.5	485.3	253.2

Exceptions to this are the Pacific Coast and Rocky Mountain Regions in which the majority of the forest area is unproductive forest land. Unproductive forest land is incapable of producing wood crops and in the West, includes chapparel areas. The third forest category is productive-reserved forest land--land that is productive enough to be commercial forest but has been withdrawn from timber utilization through statute or administrative regulation. In the Lake States, 92 percent of the forest area is commercial forest, 5 percent is unproductive, and 3 percent is productive-reserved.

Nationwide, commercial forest area has declined since 1952. The decline was observed in all regions except the Northeast, in which tree stocking on some nonforest land and wooded pasture increased and was reclassified as commercial forest:

Region	Change (Percent)
Pacific Coast	-5
Rocky Mountain	-10
South	-2
Northeast	+9
Central	-5
Prairie	-11
Lake States	-8
All Regions	-3

Commercial forest area in the Lake States has declined an average of 0.3 percent per year since 1952 (fig. 2). Since 1970, the rate of decline has slowed over that reported between 1952 and 1970.

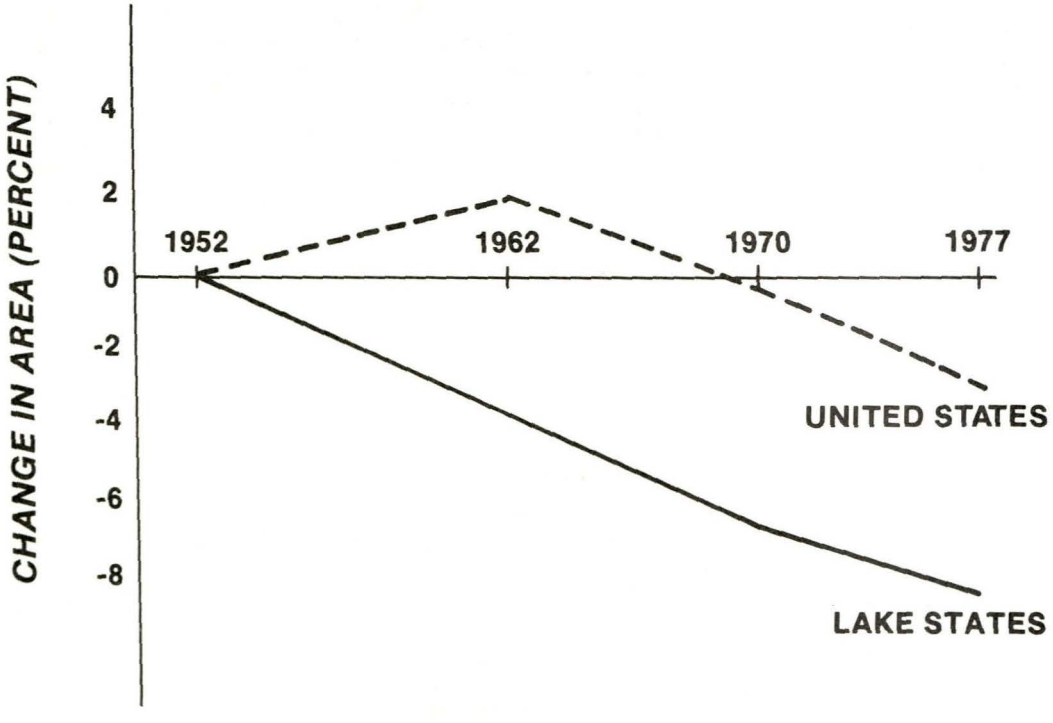

Figure 2. Change in commercial forest area, Lake States and total United States.

The majority of the commercial forest land in the Country is owned by private individuals and corporations. Farmers hold 24 percent of the commercial forest area and miscellaneous private owners another 34 percent:

Ownership Class	Commercial Forest Land	
	United States	Lake States
	(Million acres)	
National Forests	88.7	5.3
Other federal agencies	16.8	1.2
States	23.1	7.1
County and municipal agencies	6.9	4.8
Forest industries	67.9	4.2
Farmers	117.0	11.6
Miscellaneous private owners	164.9	12.8
All owners	485.3	47.0

The dominance of publicly owned commercial forest land in a region varies widely (fig. 3). In the Rocky Mountain Region, 75 percent of the commercial forest area is publicly owned, while in the South and Central Regions, only 9 percent is publicly owned. Thirty-nine percent of the Lake States' commercial forest land is publicly owned. An unusual situation exists in the Lake States--large areas of commercial forests are owned by State, county, and municipal agencies (25 percent of the commercial forest area). More than 30 percent of the State-owned commercial forest land and 70 percent of the county and municipal commercial forest land in the United States is found in the Lake States.

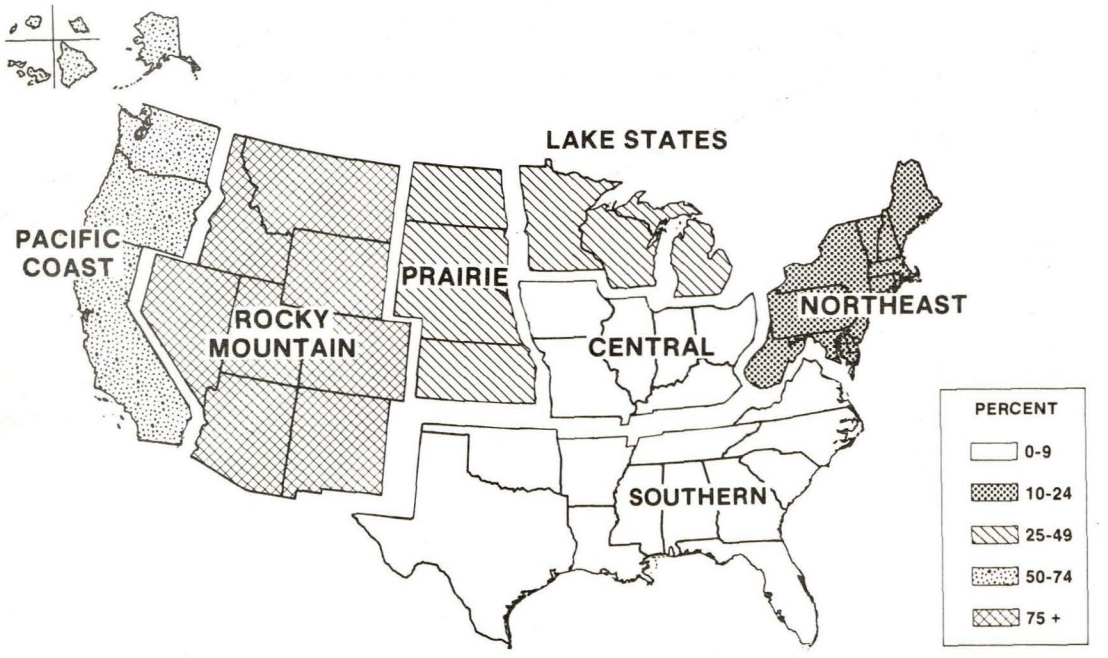

Figure 3. Publicly owned commercial forest land by region, 1977

Climatic, edaphic, and topographic factors affect the distribution of forest types across the Country. In the eastern regions (where nearly three-quarters of the commercial forest land is located) oak-hickory is the most common forest type, while in the West, Douglas fir is most common (fig. 4). The Lake States Region holds a large portion of the area of several commercially important forest types:

Forest Type	Area in eastern regions[2/] (Million acres)	Area in Lake States (Percent)
White-red-jack pine	12.0	32
Spruce-fir	17.5	42
Longleaf-slash pine	17.0	--
Loblolly-shortleaf pine	49.9	--
Oak-pine	34.5	--
Oak-hickory	110.7	5
Oak-gum-cypress	26.9	--
Elm-ash-cottonwood	24.2	15
Maple-beech-birch	33.3	30
Aspen-birch	20.5	76
Nonstocked	10.2	11
All types	356.7	13

The distribution of timber stands among stand-size classes reflects stand history and timber management practices in a region. Forty-four percent of the Nation's commercial forests is in sawtimber stands, with the remaining acreage fairly evenly divided between poletimber and seedling and sapling stands. In areas in which old-growth stands predominate, such as the Pacific Coast and Rocky Mountain Regions, more than 65 percent of the commercial forest land is in sawtimber stands (table 1). In the South, a large portion of forest area is intensively managed so forests are fairly evenly divided among the three stand-size classes. The Lake States Region is the only region that does not have the largest portion of its commercial forest area in sawtimber stands. Forty-six percent of the Lake States area is in poletimber stands, with seedling and sapling stands accounting for 23 percent and sawtimber stands 24 percent. Nonstocked commercial forest areas cover the remaining 2 percent.

[2/] Eastern regions include Lake States, Northeast, South, Central and Prairie Regions.

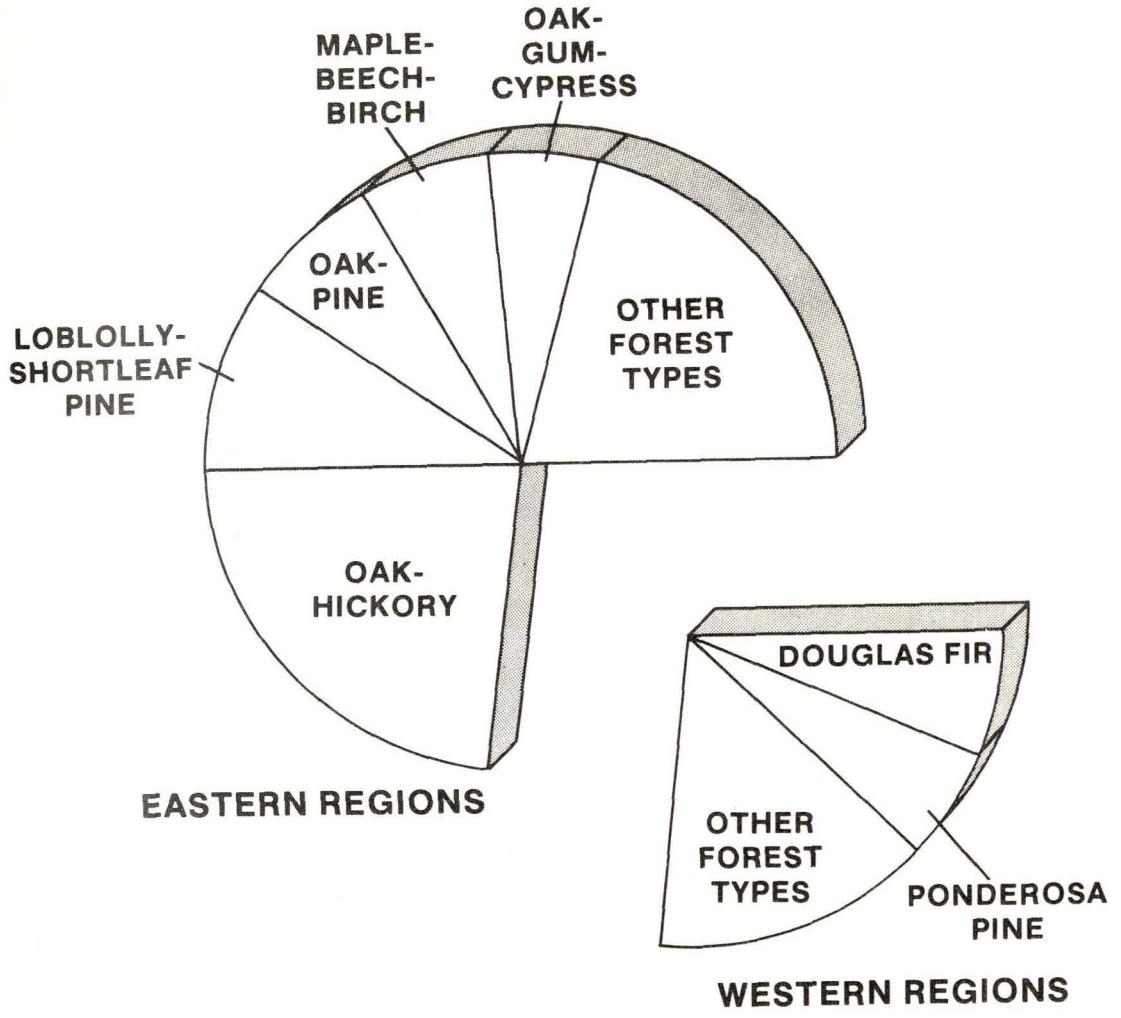

Figure 4. Distribution of commercial forest land by forest types, eastern regions and western regions, United States, 1977

Table 1.--Area of commercial forest land by region and stand-size class, United States, 1977

(In million acres)

Region	Total	Stand-size class			
		Sawtimber	Poletimber	Seedling & Sapling	Nonstocked
Pacific Coast	70.8	46.3	10.0	10.6	3.9
Rocky Mountain	56.5	37.7	11.4	4.9	2.5
South	188.4	68.4	57.3	57.6	5.1
Northeast	79.2	30.9	23.4	22.8	2.1
Central	39.6	16.4	10.8	11.1	1.3
Prairie	3.8	1.9	1.0	0.4	0.5
Lake States	47.0	11.0	21.8	13.1	1.1
Total	485.3	212.6	135.7	120.5	16.5

When compared to the rest of the Nation, the productive potential of the Lake States' forests is low. Site-class ratings assess an area's productive potential in terms of cubic feet of growth per acre per year in fully stocked natural stands at culmination of mean annual increment. The average productive potential outside the Lake States is 73 cubic feet, while the Lake States's productive potential is only 55 cubic feet.

Volume

While commercial forest area has declined, growing-stock volume has increased since 1952. Nationwide, growing-stock volume has increased 19 percent during the 25 year period. The increase in growing-stock volume of hardwoods has been more dramatic than that of softwoods.

Softwood volume rose 33.4 billion cubic feet (8 percent) between 1952 and 1977 (fig. 5). This increase was observed in all regions except the Pacific Coast Region in which softwood volume fell 12 percent. The largest percent increase in softwood volume occurred in the Lake States Region. The continuing maturation of the Region's forests resulted in a 76 percent increase in softwood growing-stock volume during the time period (fig. 6).

In the eastern regions (Northeast, South, Central, Prairie, and Lake States Regions), loblolly and shortleaf pines account for half of the 141.8 billion cubic feet in softwood species. The Lake States account for a large percentage of the volumes of several species groups, notably jack pine, eastern white pine-red pine and spruce-fir:

Species group	Softwood growing-stock volume	
	Eastern regions	Lake States
	(Billion cubic feet)	
Jack pine	1.6	1.6
White-red pine	10.8	2.4
Spruce-fir	19.5	4.1
Eastern hemlock	6.7	1.2
Other softwoods	103.2	2.6
All species	141.8	11.9

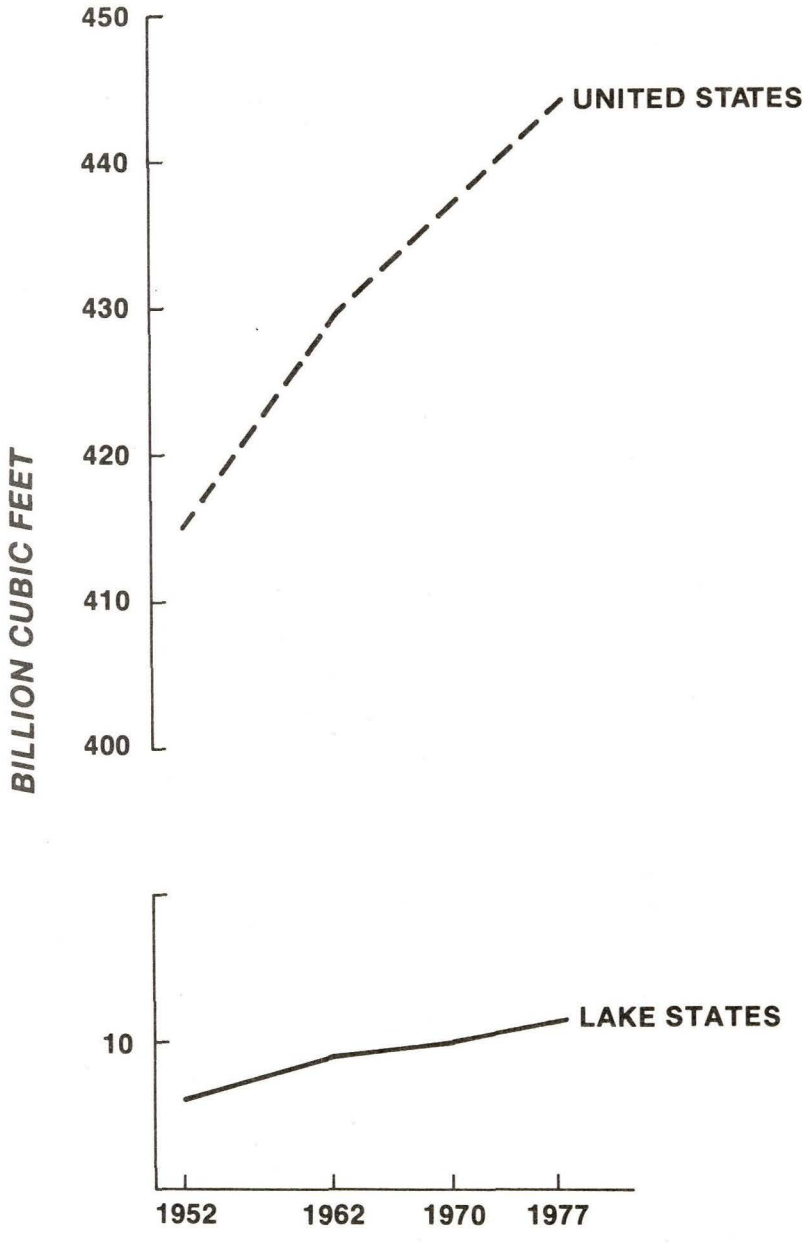

Figure 5. Trends in softwood growing-stock volume, Lake States and United States, 1952-1977

Nationwide, the National Forests account for the largest portion of the softwood growing-stock volume, 46 percent. The National Forests are not nearly so important in supplying softwood volume in the Lake States. The large concentration of Lake States' volume in other public owners reflects the importance of State, county and municipal agencies in forestry in the region:

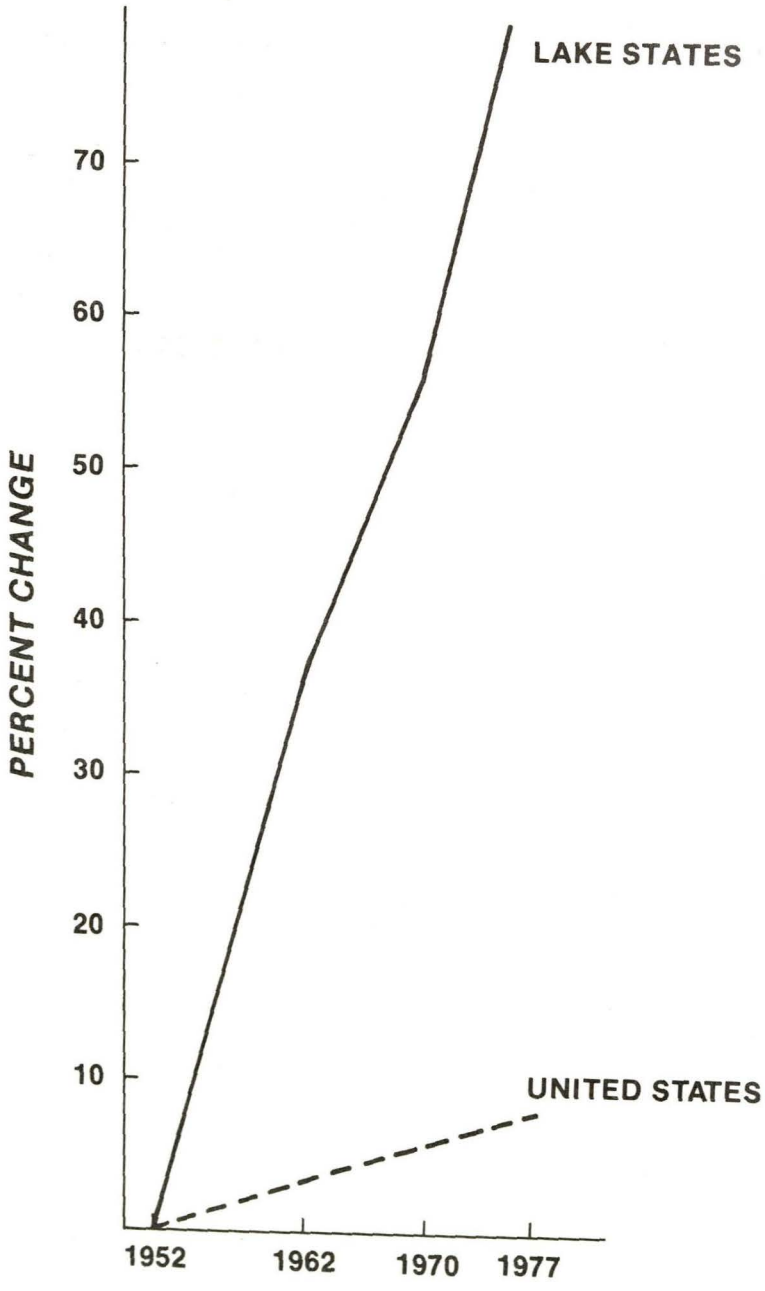

Figure 6.--Percent change in softwoods growing-stock volume, Lake States and United States

Ownership class	Softwood growing-stock volume	
	United States	Lake States
	(Percent)	
National Forest	46	18
Other public	11	30
Forest industry	16	15
Other private	27	37
All owners	100	100

An increase of 79.3 billion cubic feet (45 percent) in hardwood growing-stock volume occurred between 1952 and 1977 (fig. 7). All regions showed an increase but the 72 percent increase in the Lake States' hardwood volume was the largest of any region (fig. 8).

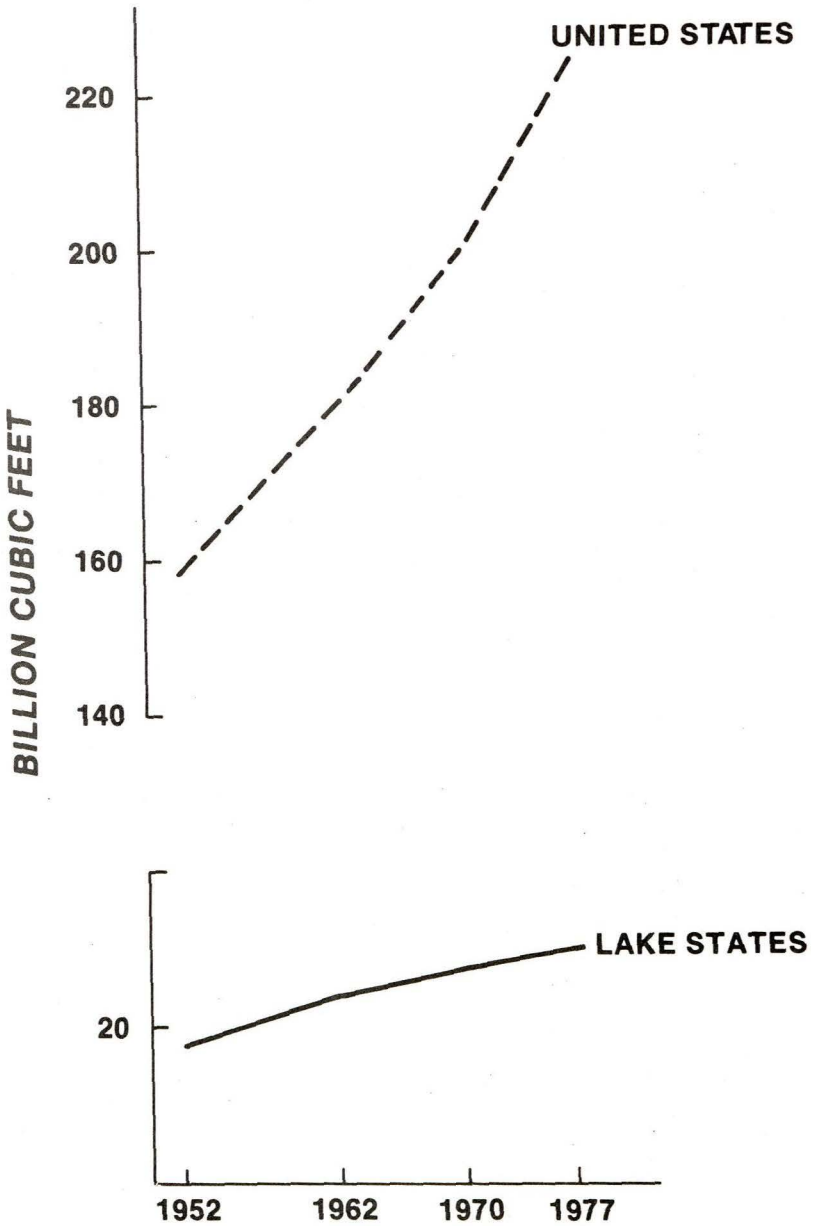

Figure 7.--Trends in hardwood growing-stock volume, Lake States and United States

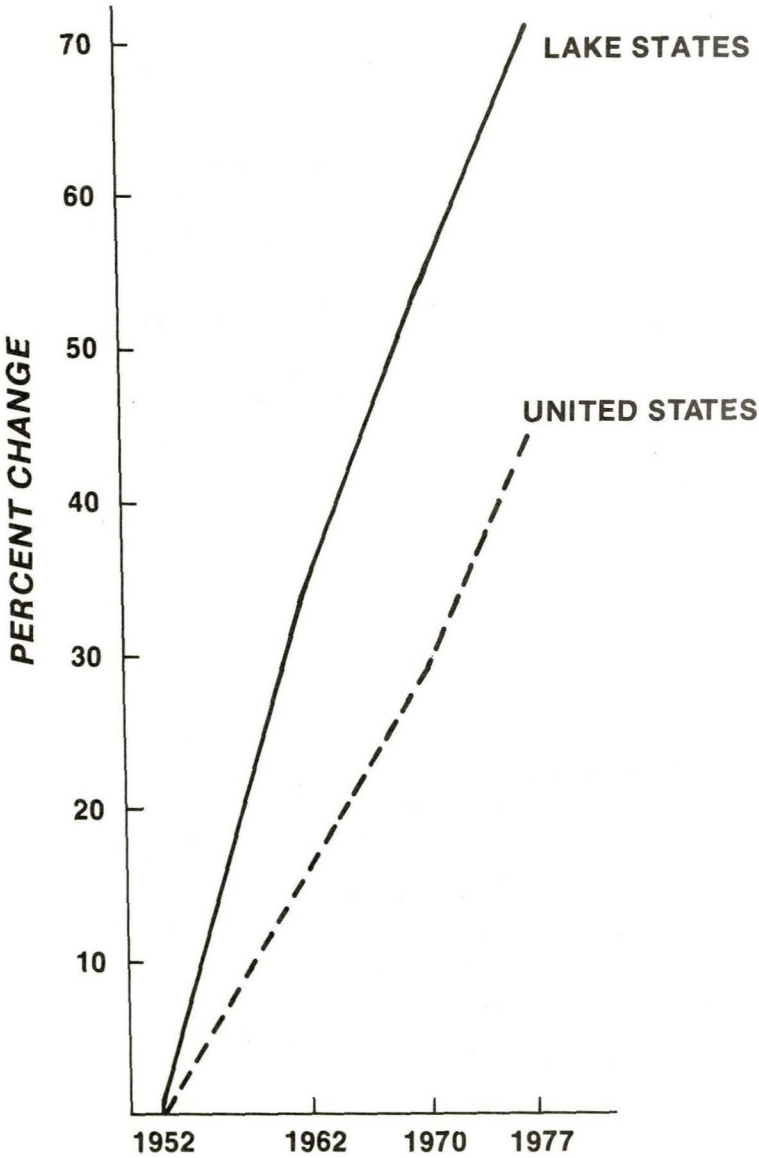

Figure 8. Percent change in hardwood growing-stock volume, Lake States and United States

The oak species account for 30 percent of the 135.4 billion cubic feet of hardwood growing-stock volume, the largest percentage of any species group. The Lake States provide 74 percent of the aspen-cottonwood volume in the East, as well as 31 percent of the ash and 23 percent of the maple volumes:

Species group	Hardwood growing-stock volume	
	Eastern regions	Lake States
	(Billion cubic feet)	
Oaks	5.8	4.8
Maples	12.1	9.0
Aspen-Cottonwood	27.5	6.4
Ash	41.2	4.9
Other hardwoods	48.8	9.3
All species	135.4	31.4

Although National Forests hold the majority of the Nation's softwood growingstock volume, they hold very little of the hardwood growing-stock volume. Again, the importance of other public owners in the Lake States is shown.

Ownership class	Softwood growing-stock volume	
	United States	Lake States
	(Percent)	
National Forest	8	10
Other public	10	24
Forest industry	12	10
Other private	70	56
All owners	100	100

Growing-stock volume increases despite declines in commercial forest area when growing-stock volumes per acre of commercial forest land also increase. In 1952 there were an average of 1,199 cubic feet of growing-stock per commercial forest acre, but in 1977 the volume per acre had increased 22 percent to 1,466 cubic feet. The differences in volumes per acre among regions reflect the distribution of commercial forest area among stand-size classes. In the Pacific Coast Region, where so much land contains sawtimber stands, growing-stock volume per acre is much higher than that of any other region. In the Lake States there are more seedling and sapling stands than sawtimber stands, growing-stock volume per acre is much lower than the national average:

Region	Growing-stock volume per acre of commercial forest land
	(cubic feet)
Pacific Coast	3,341
Rocky Mountain	1,737
South	1,067
Northeast	1,261
Central	750
Prairie	795
Lake States	921
All regions	1,466

Volumes per acre also vary widely by ownership class. Nationwide, National Forests have the highest growing-stock volumes per acre; however, in the Lake States, forest industry ranks first:

Ownership class	Growing-stock volume Per acre of commercial forest land	
	United States	Lake States
	(Cubic feet)	
National Forests	2,570	989
Other public	1,621	844
Forest industry	1,546	1,158
Other private	1,075	904
All owners	1,466	921

Growth and removals

The volume of growth and removals has increased in the Lake States and the Nation since 1952. Nationwide, growth of softwood species increased from 7.8 million cubic feet to 12.3 million cubic feet, and the growth rate (growth as a percent of inventory) increased from 2 percent to 3 percent. Increases in removals were not as great as increases in growth. In 1952, softwood removals were equal to growth but by 1977, removals were only 82 percent of growth.

Although the volume of softwood growth and removals in the Lake States also increased between 1952 and 1977, growth rates and removal rates declined. A decline in growth rates is not unusual for states in which the inventory has been increasing rapidly. In these cases, growth volumes cannot keep pace with inventory volumes and growth rates decline:

	1952	1977
Growth (thousand cubic feet)	302.5	465.3
Growth rate	4.6	3.9
Removals (thousand cubic feet)	141.8	181.0
Removals rate	2.1	1.5

In the Lake States, the ratio of removals to growth is not as high as in the Nation as a whole. In 1952, softwood removals in the Lake States were 47 percent of growth and by 1977 had declined to 32 percent of growth (fig. 9).

Hardwood growth Nationwide increased from 6.2 million cubic feet in 1952 to 9.5 million cubic feet in 1977. Growth rates increased slightly from 1.8 to 2.2 percent of inventory. Increases in hardwood removals were small from 4.1 million cubic feet to 4.3 million cubic feet. Removals rates declined from 2.3 percent to 1.6 percent of inventory during this period.

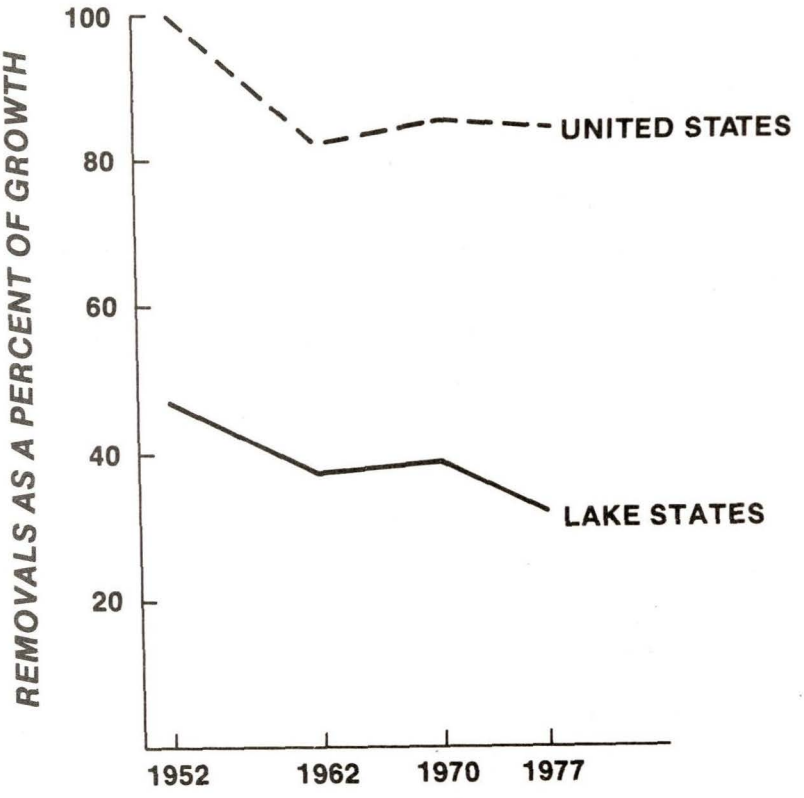

Figure 9.--Softwood growing-stock removals as a percent of softwood growing-stock growth, Lake States and United States

Although hardwood growth and removals volume in the Lake States increased between 1952 and 1977, growth and removals rates decreased:

	1952	1977
Growth (thousand cubic feet)	854.0	1,120.2
Growth rate	4.7	3.6
Removals (thousand cubic feet)	370.1	521.0
Removals rate	2.0	1.7

During the period, hardwood removals as a percent of growth increased in the Lake States as changes in technology and development of new products began to more fully utilize the hardwood resource (fig.10).

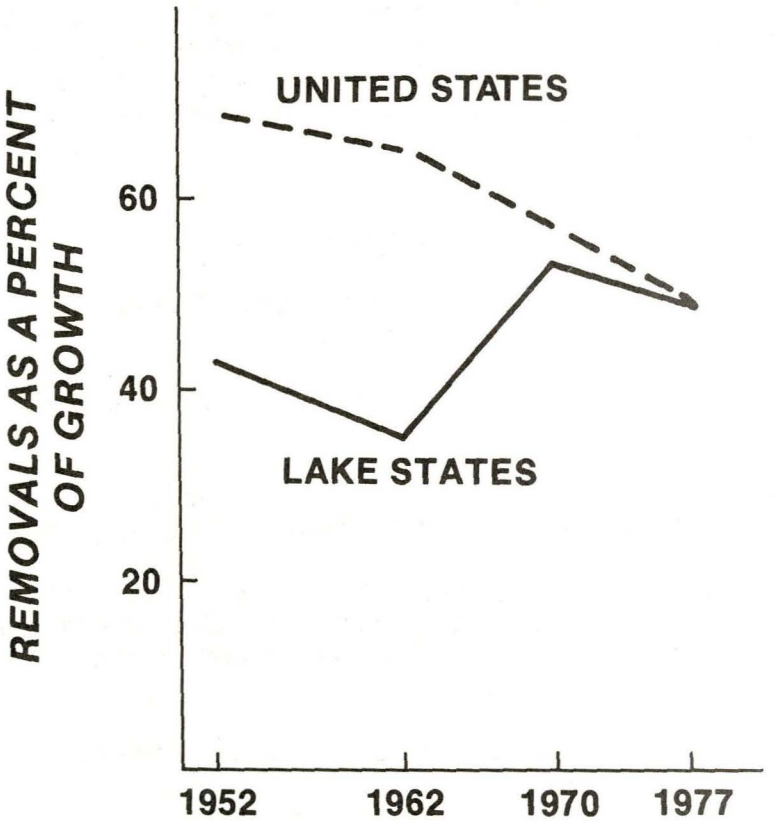

Figure 10. Hardwood growing-stock removals as a percent of hardwood growing-stock growth, Lake States and United States

Most of the growing-stock removals in the Lake States and the Nation went to products:

Removals	United States	Lake States
	(Percent)	
Sawlogs	44	20
Veneer logs and bolts	9	1
Pulpwood	24	38
Miscellaneous industrial products	2	4
Fuelwood	4	8
Logging residue	9	4
Other removals	8	25
All removals	100	100

An unusually large percentage of the Lake States' removals go to other removals. Other removals are trees actually cut or downed during land clearing or cultural operations but not used for products, and trees left standing but "removed" from the commercial forest land base due to changes in land use.

Summary

This has been a brief sketch of the Lake States' timber resource. Highlights from the discussion include:

-- Commercial forest land in the Lake States decreased 8 percent between 1952 and 1977.

-- A large percentage of the Country's State, and county and municipal commercial forest land is found in the Lake States.

-- 76 percent of the aspen-birch acreage, 42 percent of the spruce-fir acreage, 32 percent of the white pine acreage, and 30 percent of the maple-beech-birch acreage found in the eastern regions is found in the Lake States.

-- The largest portion of the Lake States' commercial forest land is in poletimber stands.

-- The productive potential of the Lake States' forests is low.

-- The percent increase in growing-stock volume in the Lake States exceeded all other regions.

-- Growing-stock volume per acre of commercial forest land is 921 cubic feet in the Lake States, compared to 1,466 for all regions.

-- Growth and removals volumes in the Lake States have increased since 1952.

-- In the Lake States, 71 percent of growing-stock removals goes to products, 25 percent to other removals, and 4 percent to logging residue.

MINNESOTA TIMBER UTILIZATION

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Primary Industry

Minnesota's primary wood-using industry is concentrated in the eastern half of the State with the largest mills primarily in northeast and north central counties (fig.1). In 1975, out of 229 active primary mills, 8 were pulpmills, 199 were sawmills, and the remainder were veneer, cooperage, particleboard, and other specialty mills. Eight sawmills each produced 5 million board feet or more of lumber and 29 others each produced from 1 to 5 million board feet.

Total timber products harvested in 1975 were 158 million cubic feet (nearly 2 million cord equivalents). Forty-four percent of the volume was harvested on farm and other small private ownerships and 10 percent was harvested on forest industry land. State-owned land contributed 20 percent, county land 12 percent, National Forests 11 percent, and other Federal land 3 percent.

Minnesota loggers harvested three major products in 1975--pulpwood (63 percent of the total), saw logs (18 percent), and fuelwood (13 percent). The remainder was in a variety of products such as veneer logs, cooperage logs, and posts.

Aspen (42 percent) dominated the timber products harvest followed by jack pine (14 percent), spruce (11 percent), oak (7 percent), and balsam fir (6 percent). Hardwoods constituted about 60 percent of the harvest.

Pulpwood

Pulpwood production was 1.36 million cords in 1975 and was concentrated in aspen, spruce, pine, and balsam fir (table 1). Unlike the other Lake States, mixed hardwood (excluding aspen) was only a small portion of the Minnesota pulpwood harvest and has never exceeded 7 percent.

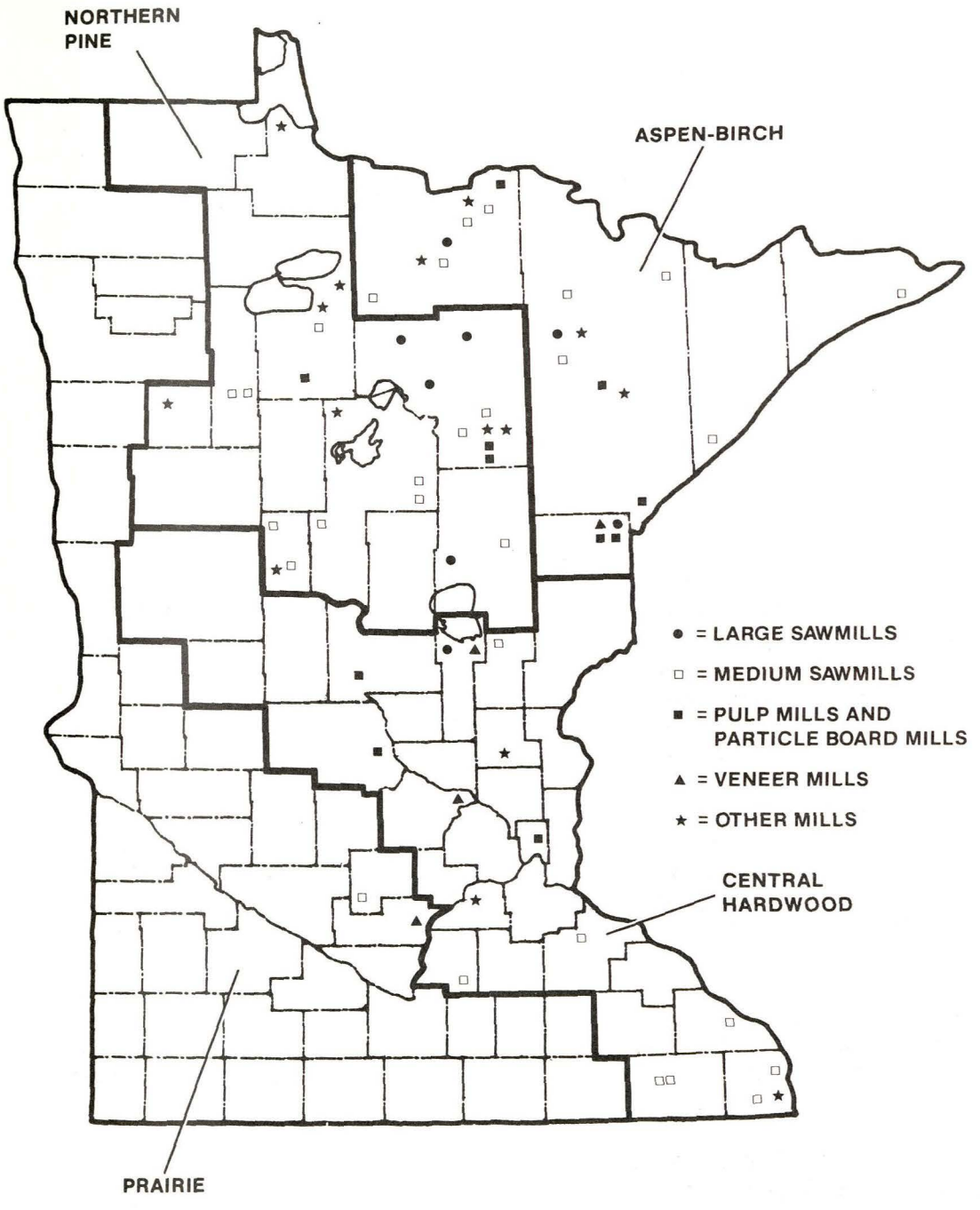

Figure 1. Primary wood-using mills and inventory units in Minnesota, 1975. Large sawmills each produced 5 million board feet or more of lumber, and medium sawmills each produced from 1 to 4.999 million board feet.

Table 1.-- Pulpwood production by species, Minnesota, 1960 and 1975

(In thousand standard cords, unpeeled)

Species	1960	1975	change
Softwoods:			
From roundwood:	645	578	-67
Spruce	256	202	-54
Pine	225	199	-26
Balsam fir	145	121	-24
Tamarack	19	56	37
From mill residue:	0	44	44
All softwoods	645	622	-23
Hardwoods:			
From roundwood:	403	673	270
Aspen	392	616	224
Paper birch	1	35	34
Other hardwoods	10	22	12
From mill residue:	0	64	64
All hardwoods	403	737	334
All species	1,048	1,359	311

Since 1950, pine and spruce pulpwood production has been in a slight downward trend but with several large annual increases and decreases (fig. 2). Balsam fir output was trendless during the 1950's, but began declining in 1961, bottomed out in 1971, and has climbed erratically since then.

Aspen pulpwood production has climbed from about 250,000 cords in 1950 to 600,000 cords or more during the 1970's (fig. 3). Overall, pulpwood harvest trends have been upward during the last 25 years.

Minnesota primary wood-using mill residue was first used for manufacturing pulp on a regular basis in 1964 and in recent years has been 7 to 8 percent of total pulpwood production.

Pulpwood production varies from year to year with changes in the business cycle and adjustments in pulpwood inventories at pulpmills. Usually annual pulpwood production gains for 1 to 3 years are followed for a year or two by declines of less magnitude.

Whole tree chips are becoming an important part of total pulpwood production. Pulpwood production from whole tree chips advanced from 69,000 cords in 1975 to 141,000 cords in 1978.

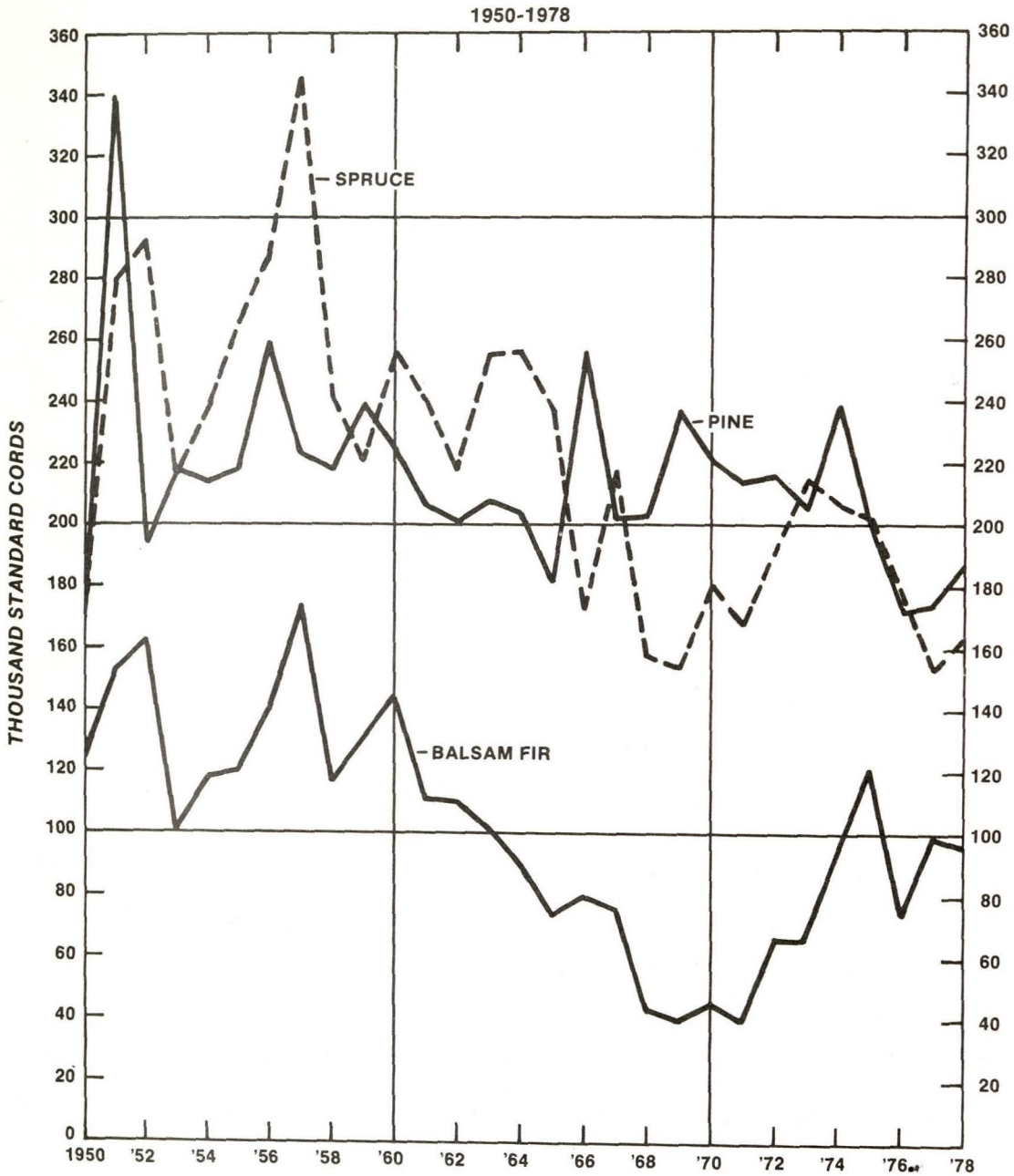

Figure 2. Minnesota round pulpwood production from selected softwood species groups, 1950-1978.

Other Products

Minnesota loggers cut 156 million board feet of saw logs in 1975, down 12 million board feet from 1960, (table 2). However, because 1975 was a recession year and 1960 was a more average year in the economy, no special significance should be attached to the lower production in 1975. In an average year, saw log production is probably higher than in 1960. Despite the low level of production in 1975, aspen and jack pine were in greater demand than in 1960. Both species are heavily used in construction and aspen is in demand for pallets and furniture stock.

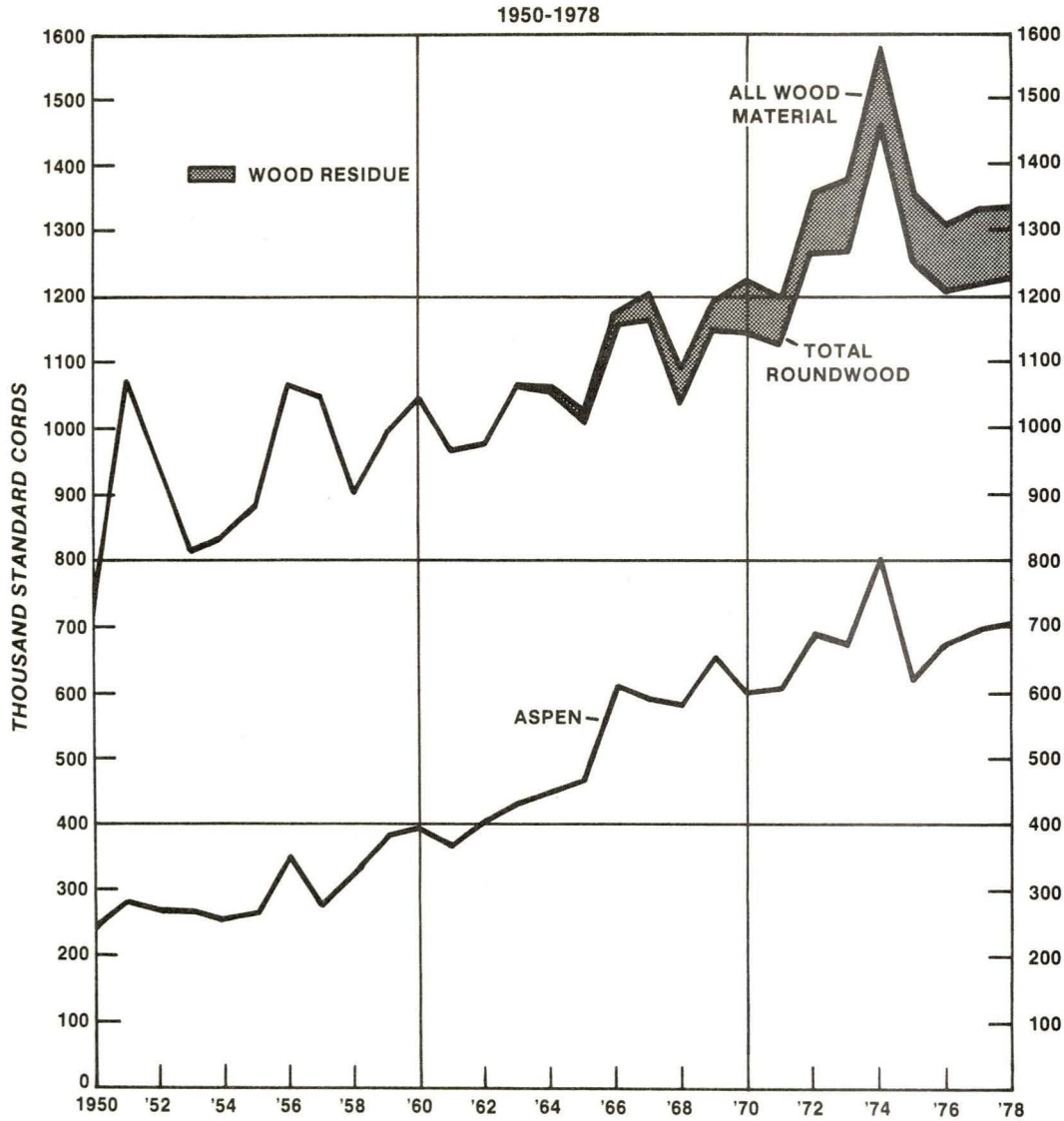

Figure 3.--Minnesota pulpwood production from aspen, all roundwood, and all wood material, 1950-1978

Minnesota exported nearly 4 million board feet of saw logs and imported about one-half million board feet. Wisconsin was the major customer for Minnesota logs and Iowa supplied the imported logs.

Minnesota produced 3.2 million board feet[1/] of veneer logs in 1975 and exported 7 out of every 8 thousand board feet. Wisconsin mills were the primary customers because they face heavy competition for veneer logs in their State. Small quantities of veneer logs are shipped to Canada and other countries. Veneer mills in Minnesota received 600,000 board feet of logs in 1975; one-third were imports from Iowa and Wisconsin.

[1/] Veneer log data for Diamond International's mill were excluded from this disucssion to keep operations at that mill confidential.

Table 2.--Saw log production by species, Minnesota, 1960 and 1975

(In million board feet, Int'l 1/4-inch rule)

Species	1960	1975	Change
Softwoods:			
Jack pine	23.4	29.0	5.6
White pine	25.7	11.3	-14.4
Red pine	16.1	10.7	-5.4
Cedar	2.0	4.6	2.6
Other softwoods	8.9	5.3	-3.6
All softwoods	76.1	60.9	-15.2
Hardwoods:			
Aspen	37.6	49.5	11.9
Oak	19.2	18.5	-0.7
Elm	8.9	9.5	0.6
Basswood	9.2	4.4	-4.8
Other hardwoods	17.1	13.3	-3.8
All hardwoods	92.0	95.2	3.2
All species	168.1	156.1	-12.0

Fuelwood production in rural areas was 343,000 cords in 1975 compared to 607,000 cords in 1960 (table 3). Primary wood-using mills supplied 41,000 cords of wood residue for fuelwood, only half the total supplied in 1960. Oak, paper birch, and aspen are the dominant species burned. An additional 200,000 cords or more of fuelwood were probably cut during 1975 in Minneapolis-St. Paul, Duluth, and other urban areas. The Minnesota Department of Natural Resources showed fuelwood production near 900,000 cords for 1978, including the urban areas.

Residue

Disposal of coarse (chippable) wood residue at primary wood-using mills is no longer a problem. In fact, only 14 percent was not used. Most of the 203,000 green tons of coarse residue generated in Minnesota in 1975 came from sawmills and veneer mills. More than half (52 percent) was used in pulp manufacturing and more than one-quarter (28 percent) as fuel.

However, more markets are needed for fine wood residue and bark residue produced at primary mills. Three-fifths of the 120,000 green tons of fine wood residue was not used. Most of the fines was sawdust and shavings. Fuel markets absorbed only 19 percent and markets for mulch, animal bedding, poultry litter, and similar products took another 14 percent.

Table 3.--Fuelwood production by species in rural Minnesota, 1960 and 1975

(In thousand standard cords)

Species	1960	1975	change
Softwoods:			
From roundwood:	45	17	-28
Jack pine	28	12	-16
Tamarack	17	2	-15
Other softwoods	--	3	3
From mill residue:	23	24	1
All softwoods	68	41	-27
Hardwoods:			
From roundwood:	480	285	-195
Oak	127	85	-42
Paper birch	45	62	17
Aspen	190	56	-134
Elm	31	28	-3
Ash	26	28	2
Other hardwoods	61	26	-35
From mill residue:	59	17	-42
All hardwoods	539	302	-237
All species	607	343	-264

Three-fifths of the 102,000 green tons of bark generated at primary mills was not used, either. Fuel was the major use, accounting for almost one-third (31 percent) of the bark.

An estimated 321,000 cords of logging residue were left after timber harvesting in 1975. Softwood residue (114,000 cords) was concentrated in the Aspen-Birch and Northern Pine Units and only 13 percent of the total was from growing stock (table 4).

Hardwood logging residue (207,000 cords) was significant in the Central Hardwood Unit as well as the northern units and a larger segment (24 percent) was growing stock than in softwoods (table 5).

Timber Removals

Timber removals from growing stock on commercial forest land has three major components--timber products, logging residue, and other removals (table 6). Other removals are growing-stock trees removed but not utilized for products or trees left standing but "removed" from the commercial forest land classification by land use change. Timber removals from growing stock was an estimated 194 million cubic feet in 1976 and timber products was the main component (70 percent). Another 28 percent was other removals, chiefly hardwoods. Lack of markets, lack of interest in marketing timber, inefficient marketing systems, and ignorance of marketing opportunities are primary reasons for the large segment of other removals.

Table 4.--Softwood logging residue by inventory unit, Minnesota, 1975

(In thousand standard cords)

Inventory Unit	Growing stock	Nongrowing stock	Total
Aspen-Birch	9	59	68
Northern Pine	6	39	45
Central Hardwoods	1/	1	1
Prairie	1/	1/	1/
All units	15	99	114

1/ Less than 500 cords

Table 5.--Hardwood logging residue by inventory unit, Minnesota, 1975

(In thousand standard cords)

Inventory Unit	Growing stock	Nongrowing stock	Total
Aspen-Birch	17	70	87
Northern Pine	19	65	84
Central Hardwoods	11	19	30
Prairie	2	4	6
All units	49	158	207

A comparison by county for 1976 of growing-stock removals from all species in cords per 1,000 acres of commercial forest land shows where timber may be over or underutilized from a sustained yield basis (fig. 4). The heaviest removals were in the Twin Cities area and in southwestern Minnesota. More than 500 cords per 1,000 acres of commercial forest land were removed from 16 counties in 1976: overcutting was likely in some of these counties. Growing-stock removals were light in northern, north central, and southeastern Minnesota for all species lumped together.

Table 6.--Timber removals from growing stock on commercial forest land by components, Minnesota, 1976

(In million cubic feet)

Component	All species	Softwood	Hardwood
Timber products	135.0	56.9	78.1
Logging residue	5.1	1.2	3.9
Other removals	53.5	10.7	42.8
Total	193.6	68.8	124.8

This pattern is also reflected in growing-stock removals as a percent of volume for all species in aggregate (table 7). However, certain individual species may have been overcut in some areas of northern Minnesota. For example, more than 6 percent of the jack pine growing stock was removed in 1976 in Carlton, Lake, Koochiching, Roseau, Clearwater, Mannomen, Aitkin, Otter Tail, Todd, and Morrison Counties. Jack pine may have been overcut in these counties. At the same time, less than 2 percent of the growing stock was removed in Cook, Crow Wing, Hubbard, and Lake of the Woods Counties and none was removed in six counties with a significant volume of jack pine in the Central Hardwood Unit. Removals of less than 2 percent annually may indicate underutilization of the jack pine resource.

These indicators of possible over and underutilization of species should be used cautiously when developing future wood procurement strategy and for making other forest management decisions because (1) sampling errors at the county level may be high for individual species, (2) wood procurement patterns and volumes change from year to year, (3) stand age structure may mask the extent of under or overutilization, and (4) apparent over or undercutting may be a temporary timber management tool to improve the stand structure and species mix.

Table 7.--Timber removals from growing stock on commercial forest land for selected species groups as a percent of growing-stock volume in Minnesota counties, 1976.

County	All species	Jack pine	Spruce	Balsam fir	Aspen	Paper birch	Oak
Aitkin	1.5	7.9	1.4	1.2	3.5	0.8	1.7
Anoka	3.8	--	--	--	--	--	3.7
Becker	0.7	2.3	0.9	1.3	0.5	0.4	0.5
Beltrami	1.6	2.8	2.7	2.8	2.3	1.2	0.6
Benton	2.0	0.0	--	--	--	--	3.3
Big Stone	3.7	--	--	--	--	--	--
Blue Earth	2.6	--	--	--	--	--	2.6
Brown	2.8	--	--	--	--	--	--
Carlton	1.1	12.8	0.4	0.5	2.6	0.9	--
Carver	8.0	--	--	--	--	--	--
Cass	1.1	2.8	0.8	0.7	1.4	0.8	0.7
Chippewa	4.2	--	--	--	--	--	--
Chisago	1.4	0.0	--	--	--	--	0.6
Clay	2.2	--	--	--	--	--	--
Clearwater	1.3	11.5	6.9	2.0	1.1	0.6	0.7
Cook	0.8	1.5	0.9	0.4	1.1	0.3	--
Cottonwood	3.6	--	--	--	--	--	--
Crow Wing	0.9	1.5	--	0.8	1.2	0.4	0.4
Dakota	5.9	--	--	--	--	--	--
Dodge	2.8	--	--	--	--	--	--
Douglas	4.6	--	--	--	--	--	--
Faribault	4.4	--	--	--	--	--	--
Fillmore	3.7	--	--	--	--	--	3.9
Freeborn	3.2	--	--	--	--	--	--
Goodhue	1.6	--	--	--	--	--	1.5
Grant	3.2	--	--	--	--	--	--
Hennepin	8.2	--	--	--	--	--	--
Houston	1.9	--	--	--	--	--	2.4
Hubbard	1.3	1.7	0.7	0.5	1.8	0.8	0.4
Isanti	1.9	0.0	--	--	--	--	2.0
Itasca	1.7	2.6	3.0	2.2	2.4	0.8	1.3
Jackson	3.8	--	--	--	--	--	--
Kanabec	1.8	0.0	--	--	1.5	0.8	1.4
Kandiyohi	2.9	--	--	--	--	--	--
Kittson	1.4	--	--	--	1.3	--	1.7
Koochiching	3.0	7.4	3.7	3.7	4.2	1.0	--
Lac Qui Parle	3.2	--	--	--	--	--	--
Lake	1.2	8.7	2.7	1.2	1.0	0.6	--
Lake of the Woods	2.3	1.9	5.3	1.1	3.2	1.0	--
LeSueur	4.9	--	--	--	--	--	--
Lincoln	3.6	--	--	--	--	--	--
Lyon	3.2	--	--	--	--	--	--
Mahnonmen	2.2	13.3	--	--	2.9	2.4	1.3
Marshall	1.4	--	--	--	1.3	--	1.6
Martin	3.3	--	--	--	--	--	--
McLeod	9.1	--	--	--	--	--	--
Meeker	4.6	--	--	--	--	--	--
Mille Lacs	3.7	0.0	--	--	8.0	1.1	2.1
Morrison	2.5	13.2	--	--	4.0	1.4	2.2
Mower	3.1	--	--	--	--	--	--
Murray	6.1	--	--	--	--	--	--
Nicollet	3.3	--	--	--	--	--	--
Nobles	8.2	--	--	--	--	--	--
Norman	1.7	--	--	--	--	--	--
Olmsted	2.6	--	--	--	--	--	2.0
Otter Tail	1.9	14.4	--	--	1.4	1.5	1.9
Pennington	1.4	--	--	--	1.4	--	--
Pine	1.3	5.8	0.6	1.0	1.4	1.2	1.0
Pipestone	7.6	--	--	--	--	--	--
Polk	1.8	--	--	--	1.4	--	1.5
Pope	3.1	--	--	--	--	--	--
Ramsey	--	--	--	--	--	--	--
Red Lake	1.4	--	--	--	1.3	--	--
Redwood	3.3	--	--	--	--	--	--
Renville	3.2	--	--	--	--	--	--
Rice	7.5	--	--	--	--	--	--
Rock	8.5	--	--	--	--	--	--
Roseau	3.8	7.6	8.3	2.3	3.1	3.6	--
St. Louis	1.6	4.5	1.8	1.0	2.4	0.5	--
Scott	6.3	--	--	--	--	--	--
Sherburne	0.8	0.0	--	--	--	--	0.9
Sibley	2.7	--	--	--	--	--	--
Stearns	2.4	--	--	--	--	--	2.7
Steele	3.2	--	--	--	--	--	--
Stevens	5.5	--	--	--	--	--	--
Swift	3.8	--	--	--	--	--	--
Todd	1.8	28.6	--	--	0.8	1.2	2.7
Traverse	6.9	--	--	--	--	--	--
Wabasha	1.3	--	--	--	--	--	1.7
Wadena	2.0	3.0	--	--	1.2	4.7	0.9
Waseca	3.7	--	--	--	--	--	--
Washington	6.5	--	--	--	--	--	--
Watonwan	4.3	--	--	--	--	--	--
Wilkin	9.8	--	--	--	--	--	--
Winona	1.5	--	--	--	--	--	1.6
Wright	2.9	--	--	--	--	--	3.2
Yellow Medicine	2.8	--	--	--	--	--	--

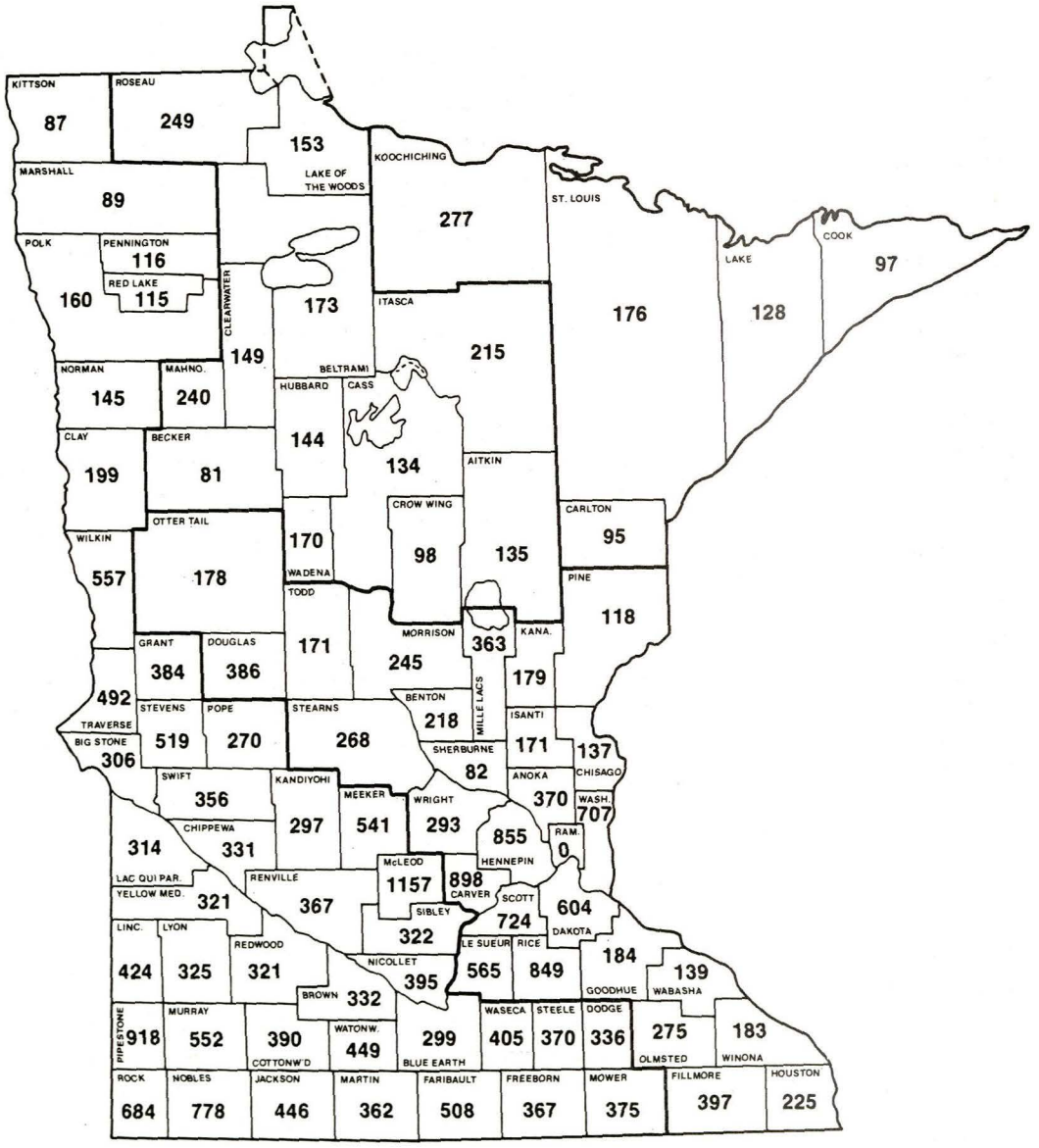

Figure 4.--Cords of timber removals from growing stock on commercial forest land per thousand acres of commercial forest land, Minnesota, 1976

(One cord=79 cubic feet of solid wood fiber.)

With this caution in mind, it appears spruce growing stock may have been overcut in Clearwater, Roseau, Lake of the Woods, and Koochiching Counties and underutilized in adjacent or nearby counties.

Growing stock removal rates for balsam fir are generally lower than for spruce and no county had a removal rate more than 3.7 percent. Thus, overcutting of balsam fir seems less likely than overcutting of spruce.

Aspen growing stock removals were 4 percent or more in Koochiching, Mille Lacs, and Morrison Counties and between 3 and 4 percent in Aitkin, Lake of the Woods, and Roseau Counties. Aspen seems to be underutilized in 13 counties in the western half of northern Minnesota where aspen growing stock removals were under 2 percent in each county in 1976. These counties are in the area near Bemidji where two waferboard plants are under construction. Aspen will be the principal species used in these mills. Other counties in which aspen removals were less than 2 percent were Lake, Cook, Kanabec, and Pine. However, Canadian mills have increased their use of aspen from Cook County since 1976.

Paper birch harvesting could be increased substantially without surpassing a sustained yield. Twelve counties in northeastern and north-central Minnesota had paper birch growing-stock removals of less than 1 percent in 1976 and eight nearby counties had removal rates between 1.0 and 1.5 percent.

Oak removals appear to be below a sustained yield level in the northern third of Minnesota--no county had a removal rate exceeding 2 percent and a seven-county block had a removal rate of less than 1 percent. In central and southeastern counties, removals seemed high in some counties but low in nearby counties, perhaps indicating removals not far from a sustained yield for these areas.

Outlook

Recent forest industry developments include construction of two waferboard plants in Bemidji and one in Cook in St. Louis County and a major expansion of the waferboard plant in Grand Rapids. A $50 million pulp mill expansion at Sartell has been announced. Other companies have recently expanded their operations or are considering further expansions. Overall, the future for Minnesota's forest industry appears bright.

MINNESOTA'S FOREST RESOURCE, 1977

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The following comments on Minnesota's forests present only the highlights of the 1977 survey. I have reduced the many long tables of information generated from the survey to a few, manageable ones.

Area

Minnesota's forest land in 1962, 18.4 million acres, represented 36 percent of the State's total land area. In 1977 the 16.7 million acres of forest accounted for 33 percent of the total. Commercial forest land dipped from 15.4 to 13.7 million acres between surveys, a decline of 11 percent. Unproductive forest dropped by 28 percent between surveys and productive-reserved forest increased 2½ times due to the creation of the Voyageurs National Park and the expansion of the reserved portion of the Boundary Waters Canoe Area.

Statistics for 1962 have been adjusted from those published after the 1962 survey to conform to 1977 statistics because of changes in the methods of determining unproductive forest and wooded pasture land between surveys.

What happened to the commercial forest land that was lost between 1962 and 1977? The largest portion (nearly 700 thousand acres) was placed in productive-reserved status as a result of legislation at the national level. Roughly 400 thousand acres were converted to urban and related uses and another 400 thousand acres were converted to cropland. Nearly 200 thousand acres were converted to other uses and to marsh and about 100 thousand acres were converted to improved pasture.

The Aspen-Birch and Northern Pine Units contain the bulk of the State's forest (table 1). The Northern Pine Unit boasts slightly more commercial forest, but the Aspen-Birch Unit contains most of Minnesota's productive-reserved forest.

Table 1.--Area of forest land by Forest Survey Unit, Minnesota, 1977

(In thousand acres)

Forest land	All units	Forest Survey Unit: Aspen-Birch	Northern Pine	Central Hardwood	Prairie
Commercial	13,695.1	5,451.4	5,758.4	1,951.1	534.2
Productive-reserved	1,178.6	1,050.6	46.9	72.4	8.7
Unproductive	1,835.5	969.8	706.9	120.2	38.6
Total	16,709.2	7,471.8	6,512.2	2,143.7	581.5

The aspen-birch forest type dominates the State's commercial forest with 50 percent of the area. The aspen type alone accounts for 39 percent of the area. As shown in the following tabulation, the 6.6 million acres of aspen-birch type in 1962 increased slightly to 6.8 million in 1977.

Forest type	Commercial forest land area: 1962	1977
	(Thousand acres)	
White-red-jack pine	1,284.6	816.9
Spruce-fir	2,921.7	2,944.1
Oak-hickory	1,022.7	893.9
Elm-ash-cottonwood	1,286.4	738.1
Maple-basswood	1,004.3	1,283.9
Aspen-birch	6,642.4	6,848.8
Nonstocked areas	1,249.7	169.4
Total	15,411.8	13,695.1

The big drop in nonstocked area does not represent actual physical change but is due primarily to use of a more sophisticated technique to determine stocking class than was used in 1962. The maple-basswood type increased in area more than any other type -- 28 percent. The white-red-jack pine type fell by 36 percent, largely because of a sharp drop in jack pine area.

Public agencies own or administer 54 percent of the State's commercial forest, and private owners account for the other 46 percent (table 2). Nonindustrial private parties own 41 percent of the total area, clearly making them the owner group with the greatest potential impact on Minnesota's forest resource. Farmers alone own 25 percent of the commercial forest.

Poletimber stands grow on 51 percent, sapling and seedling stands occupy 25 percent, and sawtimber stands grow on 23 percent of the total area, (table 3). It is not possible to accurately adjust the 1962 areas of each stand-size class in order to compare them with the 1977 areas, but it is obvious that the area of sawtimber stands increased substantially between surveys as waves of trees grew out of poletimber size in the continuing maturation of the State's forests. Sawtimber stands are most prevalent in the Central Hardwoods Unit where they represent 40 percent of total area.

Table 2.--Area of commercial forest land by ownership class and Forest Survey Unit, Minnesota, 1977

(In thousand acres)

Ownership class	Forest Survey Unit				
	All units	Aspen-Birch	Northern Pine	Central Hardwoods	Prairie
National Forest	1,715	1,153	562	--	--
Other Federal	621	126	461	25	9
State	2,650	1,132	1,229	244	45
County and Municipal	2,342	1,186	1,097	59	--
Forest Industry	772	535	234	--	3
Farmer	3,404	544	1,322	1,142	396
Other Private	2,191	775	854	481	81
Total	13,695	5,451	5,759	1,951	534

Stands aged 30 to 60 years clearly occupy the largest area as shown in the following tabulation. These stands originated from 1917 to 1947 and represent, among other things, the results of a vigorous fire protection program, an active tree planting program, and a general awareness that the old ways of high-grading the woods and letting the slash burn were no longer acceptable.

Stand-age class (Years)	Commercial forest land area (Thousand acres)
1-10	1,210
11-20	1,129
21-30	1,064
31-40	1,772
41-50	2,620
51-60	2,274
61-70	1,278
71-80	819
81-90	568
91-100	503
101-120	279
121-140	174
141+	5
Total	13,695

Table 3.--Area of commercial forest land by stand-size class and Forest Survey Unit, Minnesota, 1977

(In thousand acres)

Forest Survey Unit	Stand-size class				
	All	Sawtimber	Poletimber	Sapling and seedling	Non-stocked areas
Aspen-Birch	5,451	943	2,847	1,596	65
Northern Pine	5,759	1,226	3,082	1,380	71
Central Hardwoods	1,951	786	848	290	27
Prairie	534	180	179	169	6
Total	13,695	3,135	6,956	3,435	169

Seventy-nine percent of the commercial forest is at least medium-stocked with trees (table 4). Poorly stocked stands account for 20 percent of the area, and nonstocked areas account for 1 percent. More than one-fourth of all sapling and seedling stands are poorly stocked or nonstocked.

Volume

Volume of growing stock on commercial forest land increased 21 percent between surveys--from 9.4 to 11.5 billion cubic feet:

Species group	Growing-stock volume	
	1962	1977
	(Million cubic feet)	
Softwoods	3,384	3,477
Hardwoods	6,060	7,977
Total	9,444	11,454

Table 4.--Area of commercial forest land by stocking class of growing-stock trees and stand-size class, Minnesota, 1977

(In thousand acres)

Stocking class	Stand-size class				
	All	Sawtimber	Poletimber	Sapling and seedling	Nonstocked areas
Nonstocked	166	2	7	8	149
Poorly stocked	2,725	614	1,214	897	--
Medium stocked	7,481	1,734	3,924	1,803	20
Well stocked	3,006	716	1,660	630	--
Overstocked	317	69	151	97	--
Total	13,695	3,135	6,956	3,435	169

Softwoods volume increased a modest 3 percent, but hardwoods volume jumped 32 percent during the 15 year interim.

As shown below, sawtimber volume on commercial forest land made a 65 percent gain between surveys--from 14.9 to 24.6 billion board feet:

Species group	Sawtimber volume	
	1962	1977
	(Million board feet)	
Softwoods	6,133	8,530
Hardwoods	8,742	16,077
Total	14,875	24,607

Softwood sawtimber volume increased 39 percent, but hardwood volume spurted 84 percent.

These volume gains reflect the maturing of Minnesota's forests, further shown by the average growing-stock volume per acre that increased from 613 to 836 cubic feet (7.8 to 10.6 cords) between surveys.

In addition to the 11.5 billion cubic feet of growing stock, there are 1.2 billion of rough and rotten trees, 0.2 billion of short-log cull trees, and 0.1 billion of salvable dead trees (table 5). The total volume of timber in all classes, then, is 13.0 billion cubic feet.

Table 5.--Net volume of timber on commercial forest land by class of timber and softwoods and hardwoods, Minnesota, 1977

(In million cubic feet)

Class of timber	All species	Softwoods	Hardwoods
Growing stock:			
Sawtimber	4,732	1,719	3,013
Poletimber	6,722	1,758	4,964
Total growing stock	11,454	3,477	7,977
Rough and rotten cull	1,207	179	1,028
Short-log cull	185	27	158
Salvable dead	107	48	59
All classes	12,953	3,731	9,222

Five species--aspen, paper birch, balsam fir, spruce, and jack pine--account for three-fifths of the growing-stock volume in the State. Aspen is the most abundant species with 30 percent of the volume. Its volume increased by 22 percent between surveys. Paper birch and balsam fir volumes increased by 51 percent and 17 percent, respectively, but spruce and jack pine volumes declined 12 and 19 percent, respectively, between 1962 and 1977.

The bulk of the growing-stock volume is in trees 12 inches or less in diameter (table 6). This is largely because 85 percent of the aspen volume is in those diameter classes.

Nonindustrial private parties own 46 percent of the hardwood growing-stock volume but only 22 percent of the softwood volume (table 7). One half of the softwood volume is almost equally divided between National Forest and State land.

Almost all (98 percent) of the softwood growing-stock volume is in the Aspen-Birch and Northern Pine Units (table 8). Hardwood volume is largest in the Northern Pine Unit (44 percent of the total) with smaller volumes in the Aspen-Birch (33 percent), Central Hardwoods (18 percent), and Prairie (5 percent) Units.

Table 6.--Net volume of growing stock on commercial forest land by softwoods and hardwoods and diameter class, Minnesota, 1977

(In million cubic feet)

Diameter class (Inches at breast height)	All species	Softwoods	Hardwoods
6	2,164.4	881.8	1,282.6
8	2,755.9	876.6	1,879.3
10	2,438.7	637.2	1,801.5
12	1,672.4	397.6	1,274.8
14	972.5	234.1	738.4
16	592.0	169.9	422.1
18	348.1	119.4	228.7
20	191.0	62.4	128.6
22	122.9	47.1	75.8
24-28	144.9	44.0	100.9
30-38	39.3	6.6	32.7
40+	11.9	0.3	11.6
Total	11,454.0	3,477.0	7,977.0

Table 7.--Net volume of growing stock on commercial forest land by ownership class and softwoods and hardwoods, Minnesota, 1977

(In million cubic feet)

Ownership class	All species	Softwoods	Hardwoods
National Forest	1,871.1	871.1	1,000.0
Bureau of Land Management	37.4	22.8	14.6
Indian	374.6	136.6	238.0
Misc. federal	96.6	20.2	76.4
State	1,942.1	818.2	1,123.9
County and municipal	2,012.3	566.7	1,445.6
Forest industry	636.0	265.0	371.0
Farmer	2,706.2	383.6	2,322.6
Miscellaneous private	1,777.7	392.8	1,384.9
Total	11,454.0	3,477.0	7,977.0

Table 8.--Net volume of growing stock on commercial forest land by softwoods and hardwoods and Forest Survey Unit, Minnesota, 1977

(In million cubic feet)

Forest Survey Unit	All species	Softwoods	Hardwoods
Aspen-Birch	4,522.1	1,888.9	2,633.2
Northern Pine	5,022.9	1,509.5	3,513.4
Central Hardwood	1,546.8	76.1	1,470.7
Prairie	362.2	2.5	359.7
Total	11,454.0	3,477.0	7,977.0

A look at the volume of the State's important aspen resource by stand-age classes reveals the same bulge in the 30 to 60 year classes that exists for the area of commercial forest land by stand-age. Recommended rotation age for aspen in the Lake States varies with site index and end product. Generally, aspen on low sites (site index 50 and less) managed for fiber production should be harvested at about age 35 and aspen on high sites (site index 70 +) managed for sawtimber should be harvested at about age 60.[1/] In many areas, low site index aspen deteriorates earlier than high site aspen and should be harvested earlier. As seen in the following tabulation, a large volume of aspen exists in stands more than 60 years old, so large losses are probably occurring.

[1/] Perala, Donald A. 1977. Manager's handbook for aspen in the North Central States. U.S. Dep. Agric. For. Serv. General Technical Report NC-36 , 30 p. U.S. Dep. Agric. For. Serv., North Central Forest Experiment Station, St. Paul, MN.

Stand-age class	Volume of aspen
(Years)	(Million cubic feet)
1-10	159.2
11-20	149.7
21-30	250.3
31-40	816.6
41-50	1,443.0
51-60	1,151.1
61-70	472.6
71-80	144.1
81-90	68.1
91-100	20.9
101-120	3.8
121-140	2.5
141+	--
All classes	4,681.9

Nearly 70 percent of the sawtimber volume is in trees with a butt log of Grade 3 (table 9). The proportion of sawtimber volume in the higher grades (1 and 2) is substantially higher for hardwoods than for softwoods.

Table 9.--Net volume of sawtimber on commercial forest land by softwoods and hardwoods and butt log-grade class, Minnesota, 1977

(In million board feet[1/])

Butt log grade	All species	Softwoods	Hardwoods
1	1,756.5	533.4	1,223.1
2	5,039.0	841.8	4,197.2
3	16,919.3	7,128.0	9,791.3
Tie and timber	892.4	27.4	865.0
All grades	24,607.2	8,530.6	16,076.6

[1/] International 1/4-inch rule.

Growth

Net annual growth of growing stock declined from 364 to 349 million cubic feet between surveys--a 4 percent drop:

Species	Growing-stock net annual growth	
	1962	1976
	(Thousand cubic feet)	
Softwoods	106,789	119,781
Hardwoods	257,420	229,139
All species	364,209	348,920

Softwood growth increased by 12 percent but hardwood growth fell by 11 percent.

The growth rate was 3.0 percent of inventory in 1976 and 3.9 percent in 1962. The 1976 softwood growth rate (3.4 percent) was higher than the hardwood rate (2.9 percent).

Practically all of the softwood growth volume is in the Aspen-Birch and Northern Pine Units (table 10). Although the Northern Pine Unit accounts for the largest share of the hardwood growth, the hardwood growth rate is highest in the Central Hardwood Unit (4.0 percent).

Mortality

Mortality of growing stock amounted to 142 million cubic feet in 1976 or 1 percent of inventory. Softwoods accounted for 34 million and hardwoods for 108 million cubic feet of mortality. Cause of mortality differed significantly by softwoods and hardwoods (table 11).

Table 10.--Net annual growth of growing stock on commercial forest land by softwoods and hardwoods and Forest Survey Unit, Minnesota, 1977

(In thousand cubic feet)

Forest Survey Unit	All species	Softwoods	Hardwoods
Aspen-Birch	114,899	56,982	57,917
Northern Pine	159,792	59,123	100,669
Central Hardwood	62,295	3,562	58,733
Prairie	11,934	114	11,820
All units	348,920	119,781	229,139

Table 11.--Annual mortality of growing stock on commercial forest land by softwoods and hardwoods and cause, Minnesota, 1976

(In thousand cubic feet)

Cause	All species	Softwoods	Hardwoods
Insects	6,767	6,075	692
Disease	80,875	14,541	66,334
Fire	7,685	505	7,180
Animals	3,507	464	3,043
Weather	23,863	4,700	19,163
Suppression	19	19	--
Logging	787	132	655
Timber stand improvement	703	--	703
Land clearing	45	45	--
Unknown and other	17,290	7,247	10,043
All causes	141,541	33,728	107,813

Projections

Projections of Minnesota's timber resource were made using the Forest Service computer program, Timber Resource Analysis System. Two sets of projections were made. A continuation of recent levels of timber removals (low removals option) was assumed for one and a higher level of removals (high removals option) was assumed for the other. Separate projections were made for softwoods and for hardwoods.

Assumptions common to both low and high options were: (1) the total area of commercial forest land will decline at an annual rate of 0.31 percent, (2) radial growth will decline in relation to the increase in the basal area per acre of trees, (3) the intensity of forest management will continue at the rate indicated by recent trends, and (4) the volume of "other" removals will drop during the period as more of these trees are utilized for products.

The low removals option projection assumed that total timber removals will increase at an average annual rate of 2.7 percent (5.4 million cubic feet). Total growth is projected to be higher than removals throughout the 30-year period, but to turn down and approach removals after about 1987. Inventory increases are projected to diminish after growth turns down and to almost flatten out by the end of the period (table 12).

The high option projection assumed that total removals will increase at an average annual rate of 4.8 percent (9.6 million cubic feet). Growth is projected to be higher than removals until about 2001 when removals outstrip growth and remain higher than growth for the remainder of the period. Inventory peaks in 2001 at 14.3 billion cubic feet then declines to 14.0 billion by 2007 (table 12).

Table 12.--Removals, net annual growth, and inventory of growing stock on commercial forest land, Minnesota, 1977 and low removals option and high removals option projections to 2007

(In million cubic feet)

LOW REMOVALS OPTION

Year	Removals			Growth			Inventory		
	All species	Soft-woods	Hard-woods	All species	Soft-woods	Hard-woods	All species	Soft-woods	Hard-woods
1977	198.4	70.7	127.7	348.9	119.8	229.1	11,454.0	3,477.0	7,977.0
1987	251.8	91.7	160.1	431.7	128.6	303.1	13,229.6	3,923.0	9,306.6
1997	307.6	112.8	194.8	415.7	126.4	289.3	14,698.0	4,174.7	10,523.3
2007	359.8	127.5	232.3	375.3	121.5	253.8	15,287.2	4,205.3	11,081.9

HIGH REMOVALS OPTION

Year	Removals			Growth			Inventory		
	All species	Soft-woods	Hard-woods	All species	Soft-woods	Hard-woods	All species	Soft-woods	Hard-woods
1977	199.1	71.1	128.0	348.9	119.8	229.1	11,454.0	3,477.0	7,977.0
1987	270.3	98.5	171.8	432.1	128.5	303.6	13,148.8	3,889.8	9,259.0
1997	371.6	132.9	238.7	422.0	126.7	295.3	14,237.4	4,006.8	10,230.6
2007	485.7	166.1	319.6	392.7	122.8	269.9	13,995.4	3,750.2	10,245.2

NEW FEATURES OF THE 1977 MINNESOTA INVENTORY

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The Minnesota Forest Inventory team collected new data and used new computational methods to provide a more detailed analysis of Minnesota's timber resource in 1977. This new data includes information on insects and diseases, biomass, operability, and treatment opportunities. A new system to simplify retrieval of this data from the computer is also being used.

Insects and Disease

The field crews worked year-round but most insect and some disease damage is much easier to detect during certain times of the year than at other times. Disease damage was recorded whenever the disease was present and insect damage was recorded only when it was extensive. Because most insect damage is difficult to identify year-round, poplar borer was the only specific insect damage recorded. Diseases were identified and recorded as follows:

Disease	Tree species
Hypoxylon	Aspen
Phellinus tremulae	Aspen
Other cankers	Aspen
Scleroderris	Red and jack pine
Sirococcus	Red pine
Blister rust	White pine
Dwarf mistletoe	Black spruce
Annual cankers	Hardwoods excluding aspen
Other cankers	Hardwoods excluding aspen

The percent of commercial forest land in the aspen type in Aitkin County, Minnesota, with incidence of Phellinus tremulae and hypoxylon canker is an example of the type of data that can be compiled from the data base (figure 1).

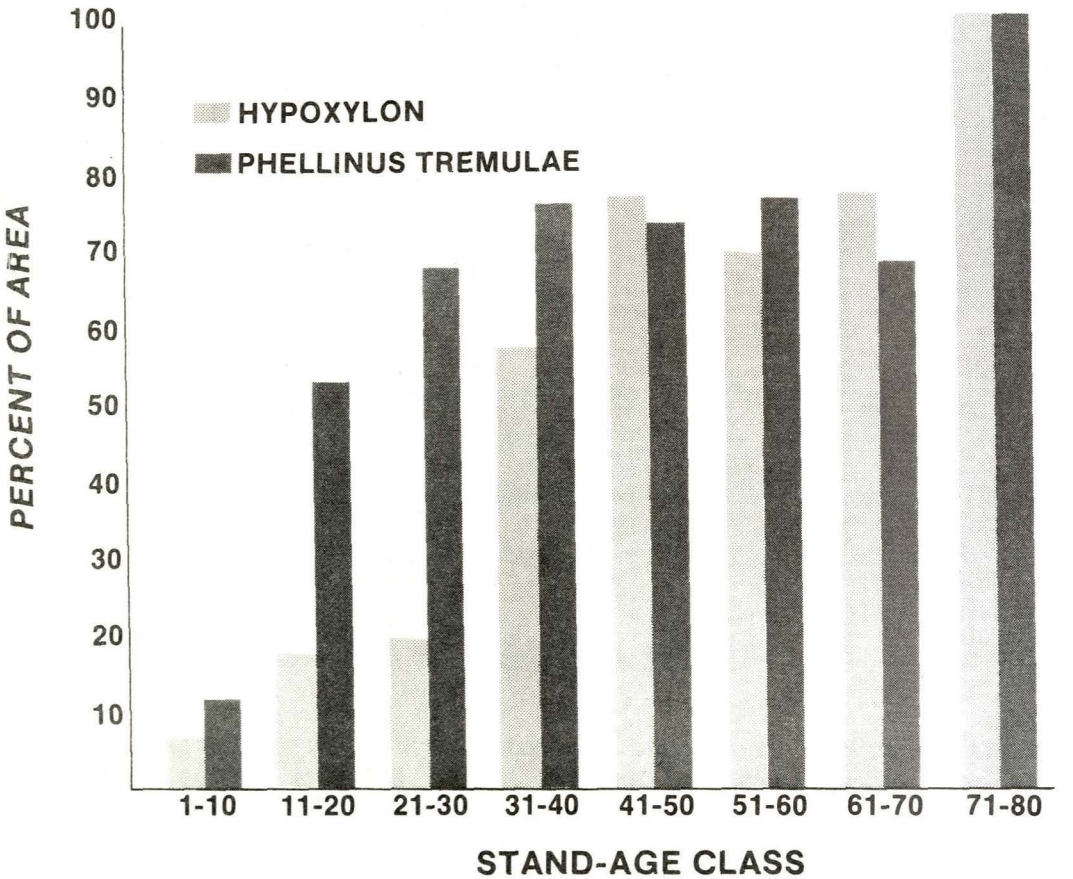

Figure 1. Aspen forest type with incidence of Hypoxylon and Phellinus tremulae on aspen growing stock, Aitkin County, Minnesota, 1977

We found that all aspen stands more than 70 years old in Aitkin County contain both hypoxylon and Phellinus and that Phellinus is more prevalent in younger stands than hypoxylon. Other examples of disease information compiled for Aitkin county are:

(1) 23 percent of the white pine growing-stock volume is infected with blister rust,

(2) 4 percent of the black spruce growing-stock volume is infected with dwarf mistletoe, and

(3) no red and jack pine are infected with Scleroderris or Sirococcus.

Biomass

An increase in demand for wood energy and fiber has increased interest in whole-tree utilization and therefore in total biomass of the State's forests. In the past, forest inventories only included volume information based on the net volume of wood in the traditional merchantable bole, which only accounts for a little more than a third of the total biomass. Today more complete utilization is taking place so biomass is presented as green tons of wood, bark, and foliage in all live tree boles, tops, and limbs for trees 1 inch diameter breast height (d.b.h.) and larger. The distribution of biomass among these components is different for hardwoods and softwoods. In Aitkin County 41 percent of the softwood biomass and 20 percent of the hardwood biomass is in trees 1-to 5-inches d.b.h. (table 1).

Table 1.--All live tree biomass by component for softwoods and hardwoods, Aitkin County, Minnesota, 1977

(In green tons)

Component	Softwoods	Hardwoods	Total
Growing-stock boles	1,867,673	11,689,202	13,556,875
Growing-stock tops and limbs	928,108	5,758,833	6,686,941
Cull boles	242,041	2,598,310	2,840,351
Cull tops and limbs	170,200	1,724,280	1,894,480
1 to 5 inch trees	2,243,779	5,244,010	7,487,789
All components	5,451,801	27,014,635	32,466,436

Operability

Traditionally, Resources Evaluation personnel have concentrated their efforts on reporting commercial forest area, timber volume, growth, and removals. Statistics on some variables affecting stand operability were available but only in a fragmented form. Analysts are now working on a study of the operability and location of Minnesota's timber resource.

Some plot variables being used in this study include physiographic class, slope, site class, stand area and volume, distance to road, and average stand d.b.h. These variables reflect the total value of timber and the cost of removal and will be used to create operability classes. These classes will then be used to analyze the forest resource. In addition, the Universal Transverse Mercator coordinates of the plots are being determined which will allow an analysis of the operability of stands within a given distance of various locations in the State.

Treatment Opportunities

One of the objectives of the Forest and Rangeland Renewable Resources Planning Act of 1974 is the evaluation of renewable resource investment opportunities. Representatives from forest industry and the Minnesota Department of Natural Resources jointly identified the harvest criteria for each forest type in Minnesota. Station personnel then used the Forest Resource Evaluation Program (FREP) to select plots needing harvest or other treatment. FREP simulated the treatments and determined the volumes removed during these treatments.

Three treatment categories were identified: (1) harvest (2) timber stand improvement (thinning and cull tree removal), and (3) stand conversion or restocking. Given the assumptions and criteria used in the analysis, 37 percent of Minnesota's commercial forest land could benefit from one of these treatments during the decade 1977-1986. However, this figure is a biological maximum only, so forest managers and planners must temper these findings to fit the resource conditions in their areas.

Management Information Systems

In Minnesota a system--called System 2000-- is being tested that allows information retrieval without writing computer programs. Data can be retrieved in tabular form or used as input for other programs that present the data in graphic form. This is the only State in the Nation to have its forest inventory statistics summarized and loaded onto a commercially available data base management system.

HOW THE STATE OF MINNESOTA USES INVENTORY INFORMATION

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The assigned topic for this presentation is "How the State of Minnesota Uses Inventory Information." A more appropriate title might be "How the State of Minnesota intends to Use Inventory Information for Forest Resources Planning". I will begin with brief descriptions of the State's inventory systems and how the data has been used in the past. I will then describe how inventory data might be used in future planning programs.

The Department of Natural Resources (DNR) refers to its forest resources inventories as Phase I and Phase II. Phase I is the forest survey carried out in cooperation with the North Central Forest Experiment Station. It provides statistical estimates of the extent, condition, volume of growing stock, growth, and depletions for all forest lands in Minnesota. Phase II data is based on compartment examinations of State-and county-administered forest lands. Phase II inventory information can be retrieved in map or tabular form for individual stands. It can also be summarized for each State Forest, county, administrative district or other geographic area.

The Long Range Plan for the Forest Management Program (MN-DNR, 1977) is an example of the use of forest resource information to project supply and demand trends and to develop long term management proposals. Inventory information is also used to develop State Park vegetation management plans.

The DNR has been using inventory information to prepare timber management plans for a number of years. The additional information collected during Phase II and enhanced data manipulation capabilities will allow the DNR to prepare more detailed and sophisticated timber management plans in the future. Bruce ZumBahlen's description of the use of inventory data to calculate allowable cuts is presented in these Proceedings.

The use of inventory information, however, goes far beyond day-to-day applications for short term management. Forest resource inventory information must be the data base for comprehensive resource management plans in which long range goals and objectives are set. Forest inventories provide the crucial information required to make the management decisions needed to improve the productivity of our forest lands.

As previously stated, the Department of Natural Resources has used inventory information to prepare timber management plans for State Forest districts. In light of current demands on our forest resources, however, these plans are not adequate to ensure a continuous flow of those resources and other services from State-administered lands. The Minnesota Department of Natural Resources is charged with the management of forest resources on nearly 5 million acres of land in the State. In addition, the Department administers a number of programs which provide incentives for forest management on private lands.

There are a number of issues which are of concern to forest management because they affect the long term availability of our forest resources. The most important of those issues are summarized here.

(1) Demands for timber and other forest resources are increasing steadily while the commercial forest land base in Minnesota is decreasing.

(2) Demands on the State's forest resources are expected to increase at a rate which will exceed the ability of the forests to satisfy those demands at the present level of management intensity.

(3) There are a number of current land use issues which affect or may affect the availability of forest resources. Among these are recreational land reservations, utility corridors, sewage sludge disposal, hazardous waste disposal and the rapidly increasing demand for fuelwood.

(4) There are ongoing comprehensive planning programs for facilities which may affect forest resources but which, because of their scope, do not take all of the forest resources into account. Some of these programs are for State Parks, wild and scenic rivers, State trails and water access sites.

These and other important issues have been under investigation by the Governor, the Legislature and the Department of Natural Resources. There is an obvious and critical need to improve and intensify the management of our forest resources. There are however, many serious questions regarding the best way to accomplish that goal. Two of those questions involve (a) the best method of providing the optimum mix of forest resource products; and (b) alternative methods of funding the improvement and intensification of forest resources management.

In an attempt to deal with these questions and the myriad of other issues and influences affecting forest management, the DNR has proposed a comprehensive forest resources planning program. That program is discussed in two documents available from the DNR's Division of Forestry and summarized here. The two documents are, Forest Resources Planning; an Analysis and Proposal, and Minnesota Forest Resources Plan - Volume 1: Planning Concept.

The DNR currently has statutory authority to develop forest plans (MS 86A.07; 86A.09 and MS 89.01, Subd 4) but has not been adequately funded or staffed for this activity.

The planning program proposed by the DNR will be aimed at satisfying the goal of improving and intensifying management of all forest resources in order to meet current and future demands. The program will include development of (1) a Minnesota Forest Resources Plan (MFRP) using the federal Resource Planning Act (RPA) where applicable as a model and (2) management plans for individual State Forest units.

Among the important objectives of the forest planning program are:

- organize resource inventory data into a system usable in forest management decision making;
- address and resolve issues pertaining to forest management;
- provide a consistent and systematic process for decision making;
- coordinate DNR forest planning efforts with those of federal, State and local agencies, private industries and associations.

The MFRP will contain a resource assessment which will examine what forest lands are producing and what they are capable of producing. A program of management will be developed using the assessment as the information base. The forest planning process is not a one-time effort. The assessment and its resulting program will be updated and revised at regular intervals.

Public involvement will play an important role in the forest planning program. One method of obtaining necessary information from a concerned public may be the formation of a task force composed of key people. Those people would serve to provide technical assistance as well as to monitor the planning process.

In order to accelerate forest management and to increase growth and yield, funding will be necessary from the State Legislature and the Federal Government. Funding will not be forthcoming without adequate planning which is accomplished with public involvement. The DNR is proposing a major forest planning program for consideration by the Governor and the Legislature, through the Legislative Committee on Minnesota Resources. The program should begin not later than July 1, 1981.

The two previously mentioned documents which discuss forest planning are available upon request from the DNR. They explain the forest planning proposal in detail and suggest several funding alternatives for the program.

The DNR has contacted a number of agencies and organizations regarding a State Forest planning program. Those who have expressed interest and who support the concept of State Forest planning are listed here.

U.S. Forest Service
State Planning Agency
State Department of Agriculture
Environmental Quality Board
Minnesota Association of Regional Commissions
University of Minnesota; College of Forestry
Timber Producers Association
Minnesota Forest Industries Information Council
Minnesota Association of Snowmobilers

A number of equally important forest user groups remain to be contacted. Support for the comprehensive forest planning proposal will be sought from all interested parties.

All citizens who make use of our valuable forest resources can benefit from a comprehensive forest planning program because the goal of that program will be to improve the resources and to ensure that they are available in a continuing supply.

For additional information, please contact the DNR Division of Forestry.

USE OF PHASE I INVENTORY INFORMATION IN DETERMINING ALLOWABLE CUTS FOR STATE LANDS

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In the absence of an intensive forest inventory on State Lands (phase II), the completion of the Statewide inventory (phase I) enabled the Minnesota Department of Natural Resources to redetermine allowable cuts as part of the overall effort to intensify forest managmeent on State lands. The economic rotation ages used in determining the recommended harvests for State lands are planning tools (table 1). They do not require every stand in a particular cover type to be harvested at a particular age. Site index and other factors would also be considered.

Table 1.--Recommended harvest by cover type on State land, 1980-1990

Cover type	Total cover type acreage (acres)	Rotation age (years)	Acres per year
Aspen	842,500	40	20,390
Birch	129,500	40	3,250
Balm of Gilead	139,200	40	3,340
Lowland hardwoods	123,000	90	1,320
Northern hardwoods	117,400	80	1,470
Oak	65,600	80	820
Spruce-fir	22,500	60	4,320
	197,700	50	
*Jack pine	93,600	50	1,726
White pine/	2,600	100	220
Norway pine	23,500		
*Black spruce	429,000	90	4,700
Tamarack	223,800	90	2,470
White cedar	202,200	90	2,000

*Until FY 1983, annual recommended harvest for jack pine will be 2,700 acres, black spruce will be 6,120 acres. Starting in FY 1983, the recommended harvest for these two types will decline to the above figures by 1990.

Part of the solution to offset the loss of softwoods caused by wilderness designations (BWCA) was to accelerate the harvest of mature stands on State lands. For a period of time, this will cause over-cutting in the jack pine and black spruce types. However, beginning in FY 1983 (July 1, 1982), the jack pine and black spruce allowable cuts will be reduced annually until they approximate their recommended levels in 1990. (fig. 1).

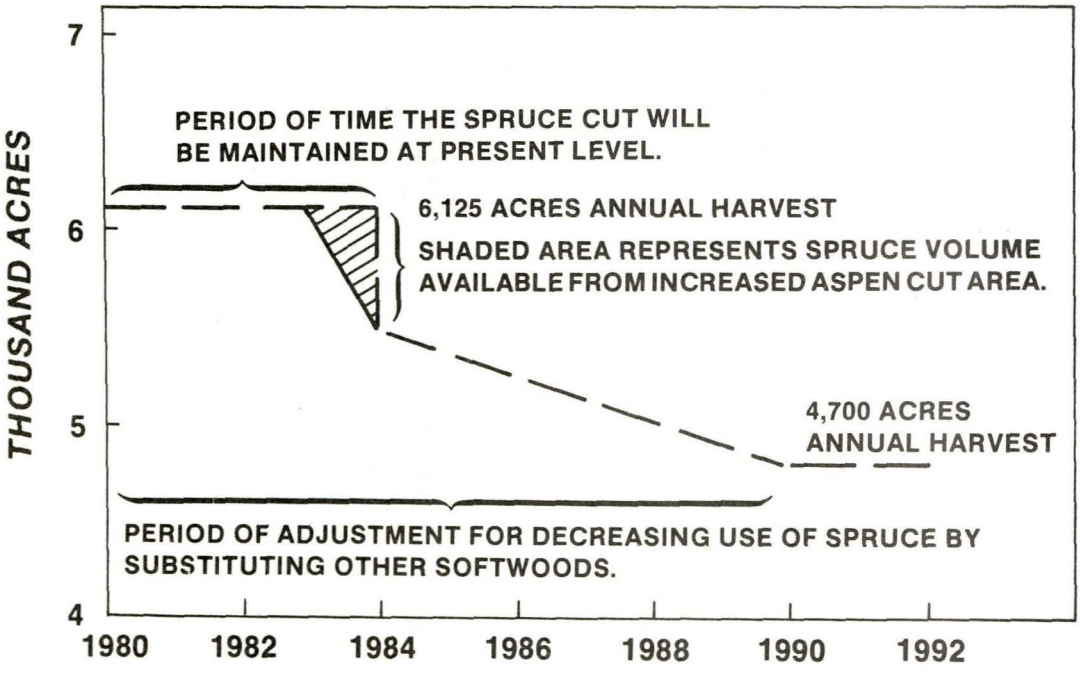


Figure 1.--Recommended harvest of black spruce type on State land in acres to year 1992.

The decline in the jack pine and black spruce allowable cuts was planned to coincide with the start-up of new industries and expansions that would utilize more of the aspen resource. The increased level of aspen harvest would make available the softwoods that are mixed in with the aspen, thus helping to replace the declining harvest in the pine and spruce types.

In order for the Statewide program to be implemented in the field, the following procedure was devised to allocate the allowable cut:

1. Compile Statewide cover type acreages from present District or State Forest management plans (as revised by Phase II).

2. Apportion the Phase I recommended harvest to each Area by comparing the Areas' cover type acreages to Statewide totals (to determine regulated cuts).

3. Adjust the regulated cuts by comparing the average age and acreage of cover types in a County/Area to their Statewide average age and acreage (to determine allowable cuts).

4. Each Area may adjust their District allowable cuts within their Area allowable cuts in order to meet the local situations.

5. Annually, the allowable cut will be revised to reflect Phase I recommended harvests and the completion of Phase II inventory projects.

Example: *Black spruce cover type

Statewide Totals			Area				
Phase I-Recommended Harvest by FY	Dist./Forest Mgt. Plans	Mgmt. Plans	Percent of Total Cover Type	Reg. Cut	Age Factor	Allow. Cut
1980-1982	6,125 ac.	475,000 ac.	30,000 ac.	.0632	387 ac.	.931	360 ac.
1983	5,500	460,000	29,000	.0630	347	.931	323
1984	5,365	450,000	29,500	.0656	352	.931	327
1985	5,230						
1986	5,100						
1987	4,970						
1988	4,835						
1989	4,700						

*Estimated for this example only. Subject to change as Phase II Inventory is completed. At some point in time, we should have sufficient data from our Phase II Inventory to regulate the allowable cuts on that basis alone.

This is how it would work:

> If an Area has 5 percent of the total jack pine cover type Statewide, it would receive an initial allocation of 5 percent of the Statewide recommended harvest for that year. In turn, this acreage would be adjusted by comparing the average age and acreage in the Area to the Statewide average age and acreage. Thus, if jack pine in an Area averaged 20 percent older than jack pine Statewide, that 5 percent would be increased by 20 percent, yielding 6 percent of the Statewide recommended harvest.

By using this procedure, we are attempting to bring into balance the Statewide distribution of age classes of a cover type so that they will be similar in each Area.

HOW THE UNIVERSITY OF MINNESOTA, COLLEGE OF FORESTRY USES INVENTORY INFORMATION

Alan R. Ek and Dietmar W. Rose, Professors
College of Forestry
University of Minnesota

Introduction

College of Forestry staff are frequent users of forest survey information. Such information serves as essential background for organizing and directing instructional and research efforts. The close physical and operational relationship that College staff have with North Central Forest Experiment Station staff frequently allows for greater opportunities in use of survey data than for other groups. Both the College and North Central Forest Experiment Station utilize the same University of Minnesota computer facilities and many of the same software packages, particularly the System 2000 data base management package, on which much of the survey data is resident. College staff also have an inside track on the availability and utility of National Forest survey efforts and associated data by virtue of undergraduate and graduate training efforts. Many North Central staff, at one time or another, have been students under the guidance of College of Forestry faculty. Because of these factors, College of Forestry staff have been effective users of the 1977 survey data we are discussing today for a period of over two years.

Our intent here is to describe some of the uses we make of inventory data for research and what might be called direct project use. The latter refers to use of the data to meet the objectives of projects sponsored by a variety of public or private groups. The emphasis for most of these projects is on economic analyses. In view of our long and frequent usage of survey data, we will also attempt to describe our experience in terms of shortcomings and opportunities we see for the forest survey, its users, and the data base.

Measurements and Inventory Research

The College has traditionally been involved in much measurement and inventory research associated with the forest survey. Recent efforts have concentrated primarily on the assessment of sampling design alternatives, particularly on alternative approaches to developing more information from the data base more efficiently. Such efforts can be broken into four categories:

1. James-Stein and empirical Bayes approaches to the use of prior information for volume and acreage estimation.

This is a research effort geared to obtaining better county level statistics. James-Stein estimation and empirical Bayes approaches are both probability based techniques for utilizing prior or existing information to improve the efficiency and accuracy of estimates. As an example, traditional procedure leads to the estimate of quantities in Itasca County based only upon the data in that county. James-Stein and empirical Bayes approaches allow us to use data from surrounding counties to improve estimates for a particular county. Gains in precision of 20 to 50 percent are common. As an alternative to increasing precision, fieldwork for the maintenance of present level of precisions may be reduced on the order of 15 to 30 percent. The net effect of such tools to the users will be important, but rather transparent. Their use may be evident only by a footnote at the bottom of customary tables indicating their nontraditional derivation. While these techniques are helpful in the state and regional forest survey efforts, they also are applicable to State and county lands in phase II inventory efforts of the DNR and county forestry departments.

2. Forest covertype area estimation

The above estimation approaches are being considered in conjunction with large and small scale aerial photo coverage as a means of omitting ground checks for forest land classification and for improving the precision of estimates of forest covertype area. It is clear from past forest surveys in Minnesota that volume and other quantities per acre for particular cover types, say, jack pine pole-sized stands, has remained relatively constant over several decades. The acres or amount of acreage in such classes, however, has changed--stands have moved to larger size classes or have been converted into other species classes. Much of survey, then, is geared to identifying the dynamics of the acres involved among the covertypes. It is anticipated that large and small scale aerial photo coverage together with empirical Bayes concepts can lead to improved inventory speed, precision, and reduced sampling costs (see Figure 1). Current emphasis is on the development of a forest sampling simulator for such designs. This work is being facilitated by several staff at the College, including the Remote Sensing Laboratory.

3. Growth and yield projection model development

The availability of the forest survey data base allows numerous analyses of alternative managment practices. To aid in this, the North Central Station has developed the FREP program STEMS growth projection model. College staff have also developed an operationally oriented projection model called MFPS, based on STEMS, that is geared to the analysis of silvicultural and economic alternatives from this data base (see Ek et al. 1980). The MFPS program plus a condensed survey data file allows analysis of many utilization and supply questions for the future in a rapid manner.

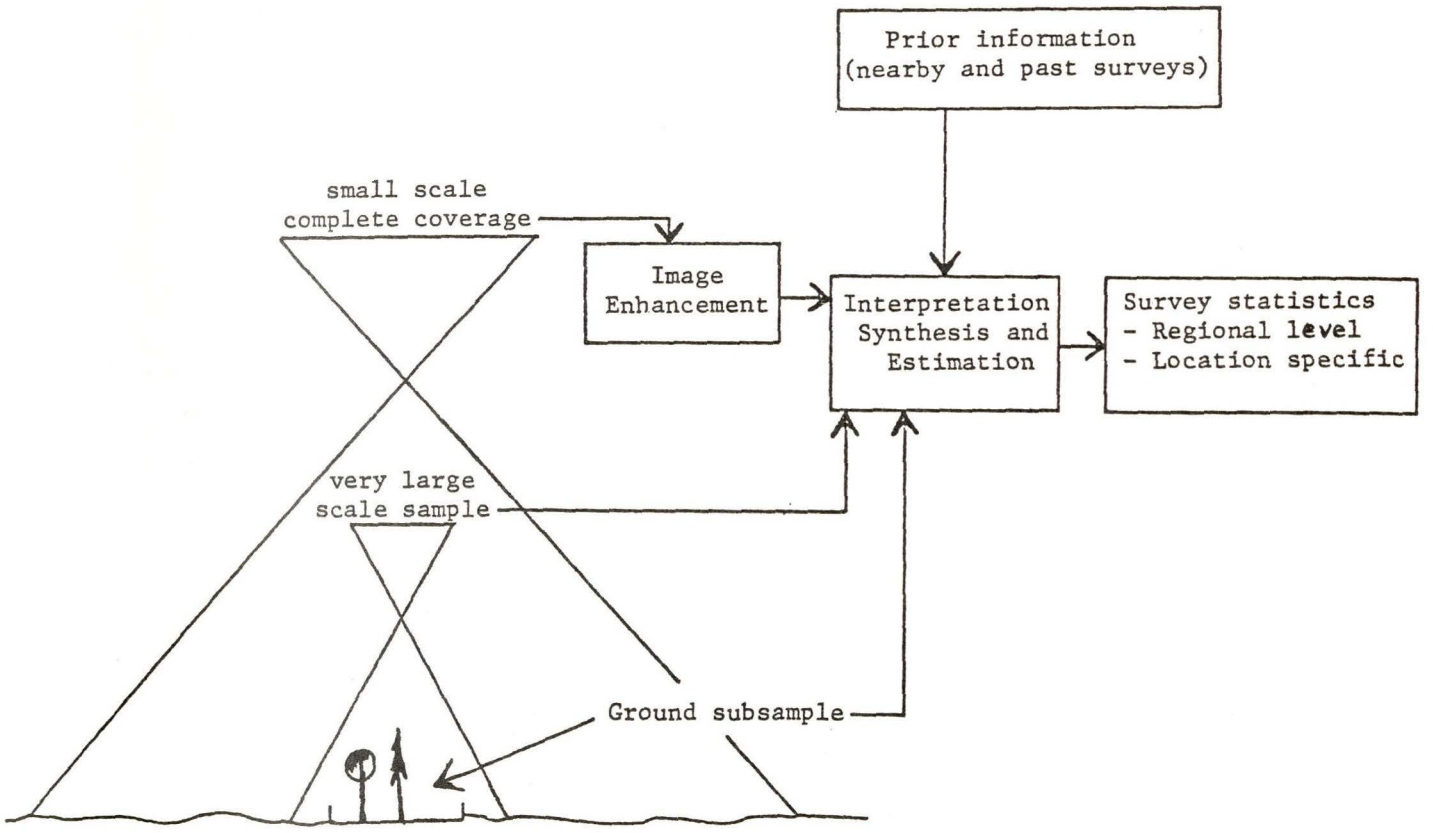
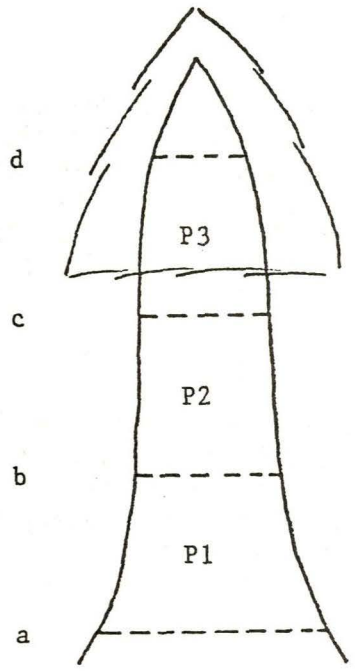


Figure 1.--A potential sampling design for forest surveys.

4. Implication of tree utilization changes via volume and taper models

The availability of the data base allows reprocessing of the inventory for entire regions or subsets with multi-product utilization conversions that allow addressing supply questions for particular products or combinations of products which trees might be broken into. Recent work in the College has led to taper curves for developing such multi-product volume tables. The illustration below (Figure 2) indicates how the product volume of a tree section can be derived.



$$P2 = \pi \int_{b}^{c} Y^2 \, dX$$

where Y = diameter from taper model
X = distance from tree tip

Figure 2.--The volume in the section from b to c can be derived by taper equation integration and sorted to product categories (e.g., P2) based on the section top diameter. Other product volumes can be derived in a similar manner.

Use of Forest Survey Inventory in Economic Analysis

Inventory data are currently being used extensively in research projects emphasizing timber management aspects of the forest resource. This reflects on the one hand the prevalence of traditional inventory data, e.g., volumes, heights and basal area of trees, but it also emphasizes the importance of timber management for other forest uses. Regulation of the severely unbalanced aspen inventories in the State through increased cutting activity, for example, is necessary to improve deer and grouse habitat and will also provide better access for recreation and other forest management activities.

This section describes five ways in which Forest Survey data are being used in analyzing and modeling forest resource decisions. They are:

(1) Physical timber supply estimation
(2) Economic timber supply (transportation and access analysis)
(3) Timber harvest scheduling and allowable cut calculations
(4) Analysis of timber investment opportunites
(5) Regional impact analysis

It is not possible to describe in detail each of these applications. We will, however, show examples of the various ways in which inventory data support such analyses.

1. Physical timber supply

Physical timber supply data were generated in the form of summaries by regions, owners, covertypes, and site index and age class combinations by a summary program to convert raw data into a form useful for economic analysis. One of the features of our summary program is the generation of data not recorded in the inventory. Examples of the latter are total and harvestable biomass, and various wood gross energy equivcalents (see Table 1).

2. Economic timber supply (transportation and access analysis)

Physical timber supply data have limited usefulness for economic analyses of timber production. Many stands are not accessible or are far from markets. Thus, the cost of making stands accessible and transportation costs must be analyzed. Figures 3-6 illustrate results of an analysis of transportation costs and timber supplies by distance class for State-owned aspen stands over 50 years old with Bemidji as the market center.

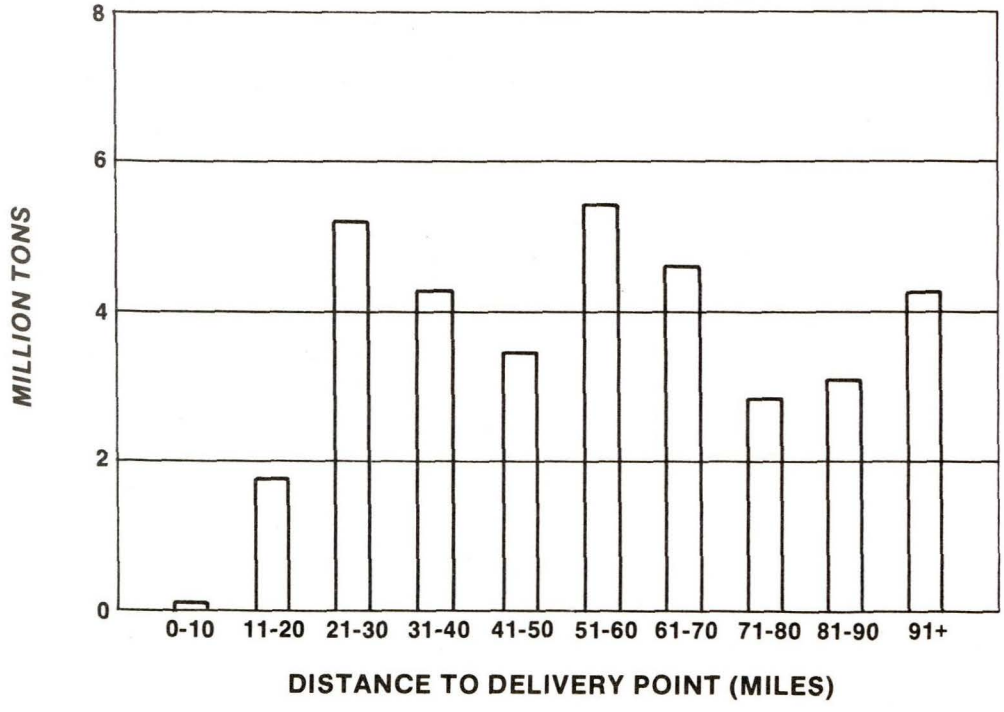


Figure 3.--Volume by weight of publicly-owned, mature hardwoods in the aspen forest type in Minnesota's Northern Pine Unit in relation to its distance from Bemidji.

Table 1.--Total biomass in tons
for all ownerships, Minnesota,
Northern Pine Unit

AGECLASS	5	15	25	35	45	55	65	75	85	95	>105	TOTAL
OAK-HICKORY												
S <40	2386	0	0	0	0	0	40904	0	0	0	0	43291
I 41-50	9925	0	0	0	94855	77862	0	0	49234	0	0	231878
T 51-60	0	0	0	34280	149626	184926	59042	0	0	0	0	427875
E >60	0	0	0	0	291018	144246	0	0	0	0	0	435265
TOTAL	12312	0	0	34280	535500	407036	99947	0	49234	0	0	1138312
LOWLD HDWDS												
S <40	11634	53183	12873	34122	0	56640	0	40514	136496	0	237293	582758
I 41-50	0	0	78787	32340	0	149830	103312	80753	0	0	0	445023
T 51-60	22291	27830	0	43605	115155	149370	114203	426342	122792	0	0	1021591
E >60	0	0	0	46834	245011	146333	0	13197	0	0	121274	572649
TOTAL	33925	81014	91660	156901	360166	502175	217515	560807	259288	0	358567	2622022
NORTH HDWDS												
S <40	0	23787	0	0	0	0	0	0	0	0	0	23787
I 41-50	0	0	46926	0	0	197736	92219	49936	94531	64825	56841	603016
T 51-60	0	44639	9563	35084	272002	449934	216107	434280	123287	0	72739	1657638
E >60	1749	0	0	137025	319061	653365	198729	0	0	255816	0	1565746
TOTAL	1749	68426	56489	172109	591063	1301036	507055	484217	217819	320641	129580	3850189
ASPEN												
S <40	6996	456	20769	12402	25594	0	121650	0	0	0	0	187869
I 41-50	80178	257118	63795	69270	112218	414346	157017	109485	62551	0	145800	1471780
T 51-60	117556	434674	121375	368810	274554	492229	180583	232674	119767	0	0	2342227
E >60	454829	495815	884488	4108068	5144981	3619886	1861737	46988	0	0	0	16616797
TOTAL	659560	1188066	1090429	4558552	5557349	4526462	2320988	389147	182319	0	145800	20618674
PAPER BIRCH												
S <40	0	31640	0	0	0	61024	0	0	126161	0	0	218826
I 41-50	39113	0	0	25792	21299	65188	18138	87618	0	0	45798	302949
T 51-60	0	20134	0	0	132659	104015	30205	0	0	0	0	287015
E >60	30786	0	113638	335315	708884	413784	292151	0	0	0	0	1894561
TOTAL	69900	51775	113638	361107	862843	644013	340495	87618	126161	0	45798	2703352
BALSAM POP.												
S <40	29098	5738	8070	0	0	26209	0	0	0	0	0	69117
I 41-50	7080	76119	101364	249035	5027	46467	38368	0	0	0	0	523463
T 51-60	70872	133257	77396	42336	182946	153017	10980	76710	0	0	0	747518
E >60	57761	128318	50797	155459	225741	545001	333844	0	0	0	0	1496923
TOTAL	164813	343434	237628	446831	413715	770696	383193	76710	0	0	0	2837022
OTHERS												
S <40	691847	605525	836448	967657	496742	693293	534135	673982	1271553	340682	1814110	8925978
I 41-50	73444	221286	492503	116460	433725	1021987	747102	399561	322058	136664	278697	4243491
T 51-60	74234	75096	224347	71884	744474	778707	240620	483424	0	138074	0	2830864
E >60	55350	49032	277263	258250	346266	609391	601408	0	0	0	0	2196962
TOTAL	894876	950940	1830563	1414253	2021209	3103379	2123267	1556968	1593611	615420	2092808	18197297
GRAND TOTAL	1837137	2683656	3420411	7144034	10341846	11254799	5992463	3155469	2428434	936062	2772556	51966870

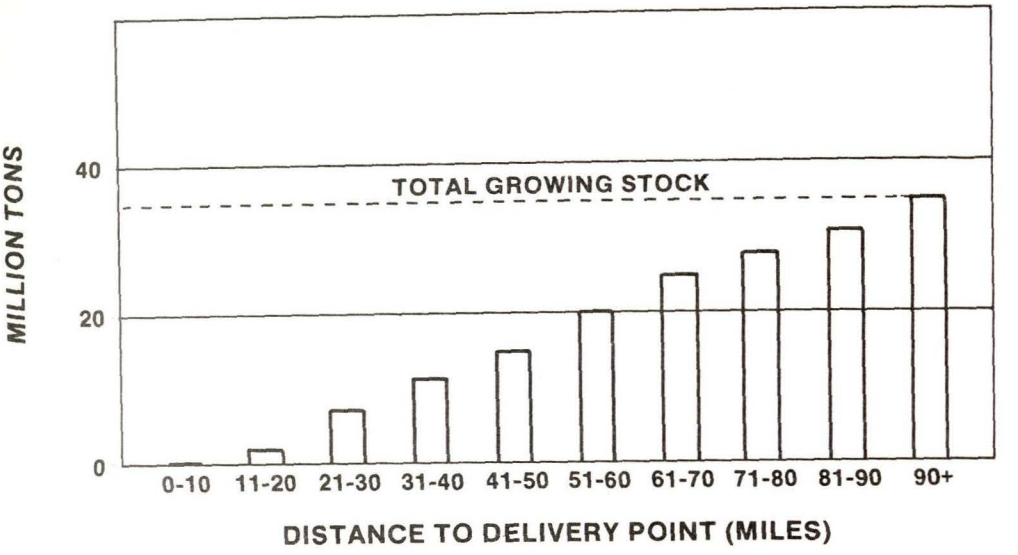


Figure 4.--Cumulative volume by weight of publicly-owned mature hardwoods in the aspen forest type in Minnesota's Northern Pine Unit in relation to its distance from Bemidji.

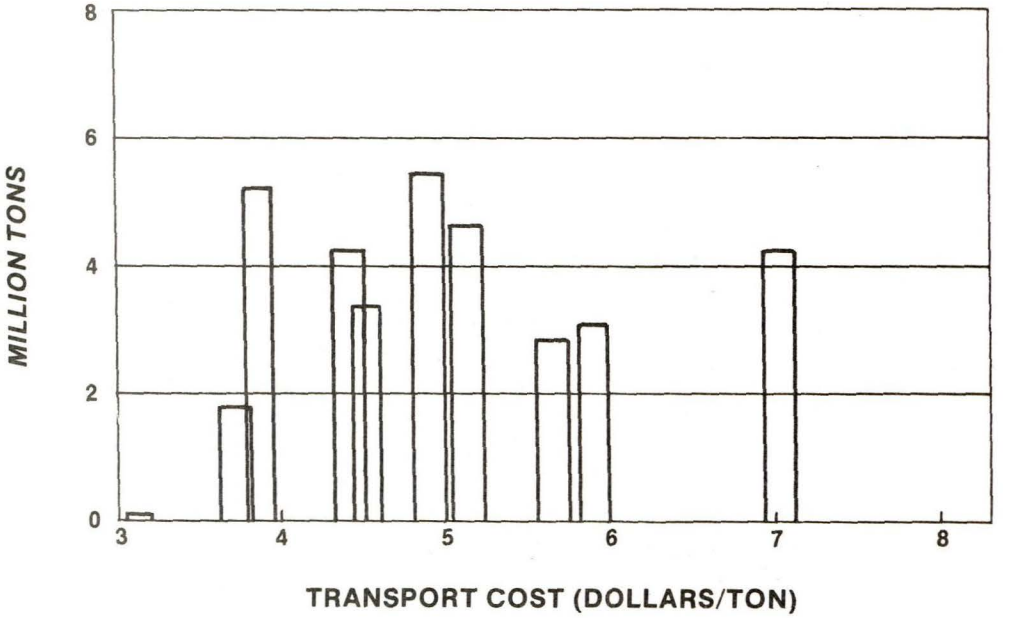


Figure 5.--Transport costs to Bemidji for volumes by weight of publicly-owned, mature hardwoods in the aspen forest type in Minnesota's Northern Pine Unit.

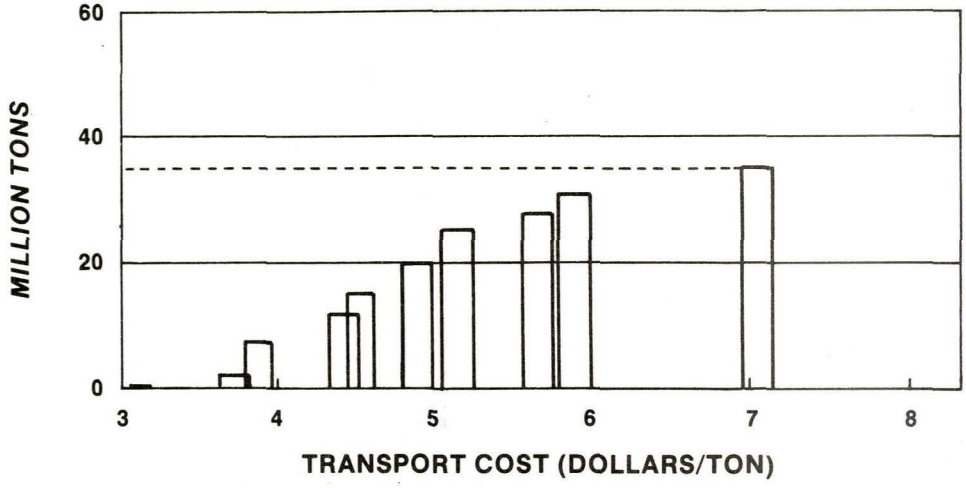


Figure 6.--Cumulative transport costs to Bemidji for volumes by weight of publicly-owned mature hardwoods in the aspen forest type in Minnesota's Northern Pine Unit.

3. Timber harvest scheduling and allowable cut calculations

The scheduling of timber cuts over time is important to achieve the goal of full regulation and to determine long-run sustainable cutting levels over time for specific covertypes and ownerships. Regulation can utilize many different procedures, each with its own implications for growth, growing-stock volume, and allowable cut. To examine implications of various regulation methods and cutting levels, a simulation model was developed to project timber inventories over time (Rose and Burk 1980).

Figures 7-10 present results of a simulation of the Tabular Check volume control procedure for State-owned aspen in survey unit 2 in terms of growing stock, allowable cut, and age class distributions.

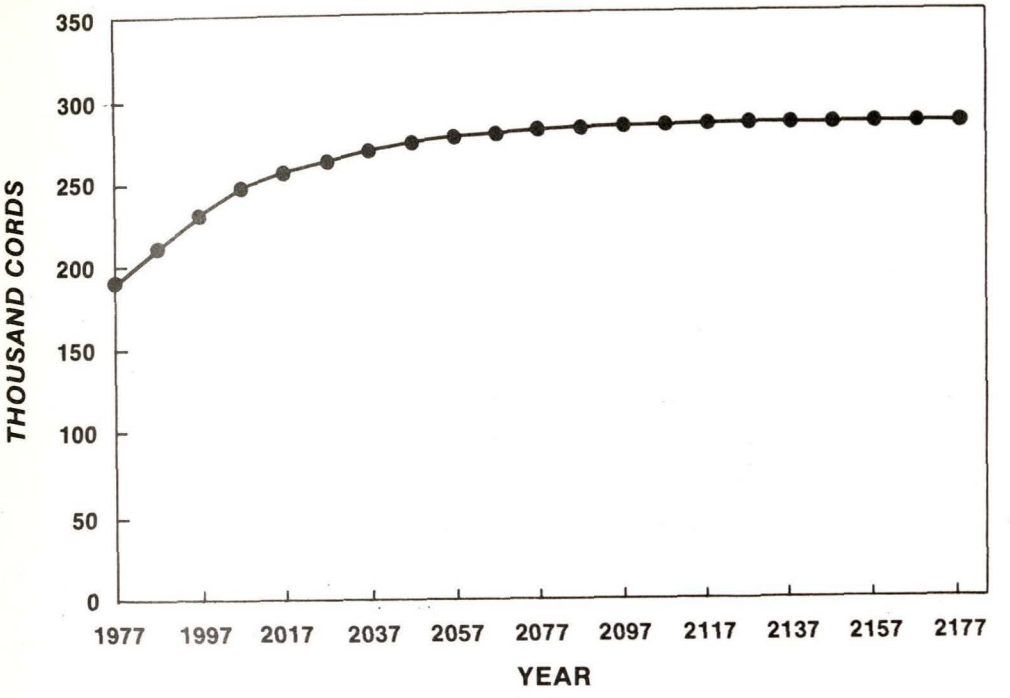


Figure 7.--Aspen allowable cut levels for State-owned lands under management in Minnesota's Northern Pine Unit.

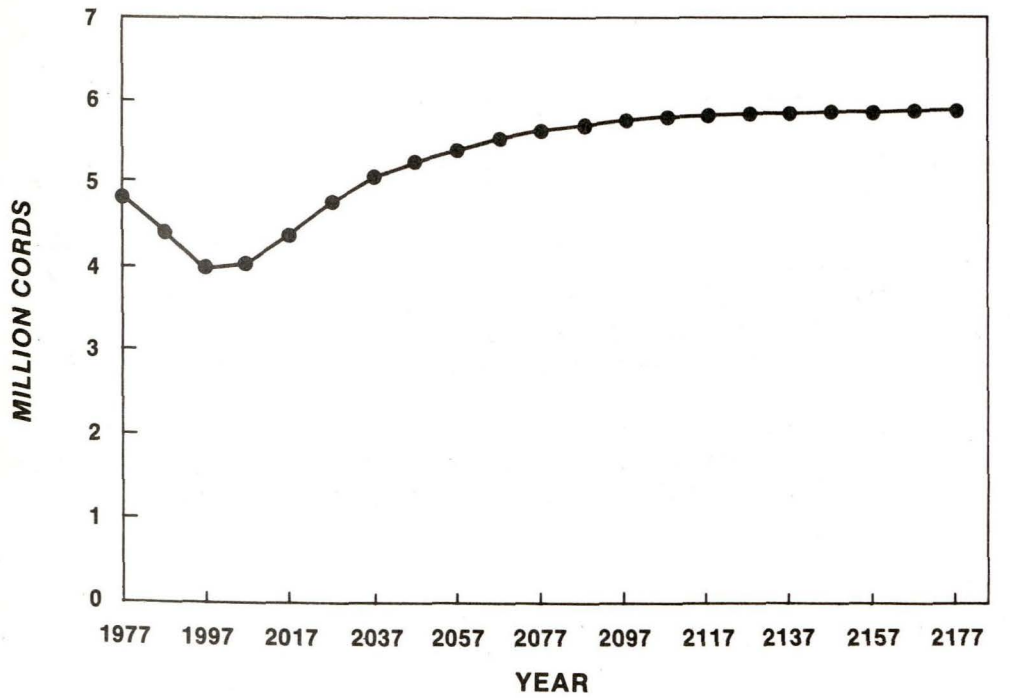


Figure 8.--Aspen growing-stock inventory levels on State-owned lands under management in Minnesota 's Northern Pine Unit, if allowable cut levels shown in Fig. 7 are maintained.

Figure 9.--Area of State-owned commercial forest land in the aspen forest type by age class in Minnesota's Northern Pine Unit in 1977.

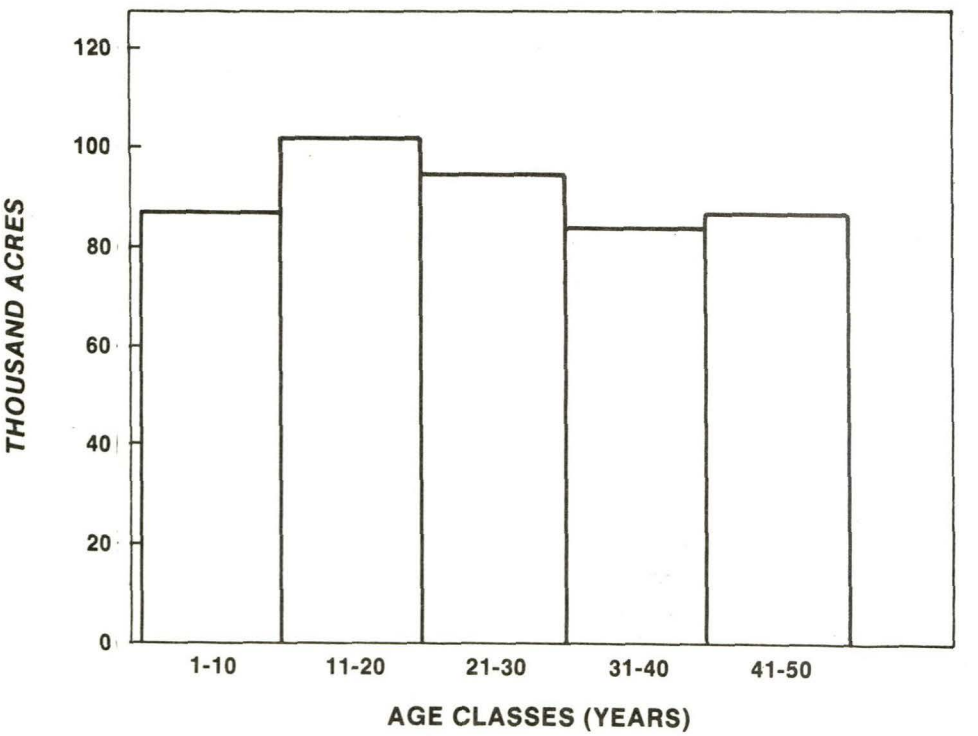


Figure 10.--Area of State-owned commercial forest land in the aspen forest type by age class in Minnesota's Northern Pine Unit in 2027, if allowable cut levels shown in Fig. 7 are maintained.

Other studies are underway which deal with scheduling of cuts by cutting priorities based on observations recorded for individual plots or stands. Sorting procedures used to establish cutting priorities are being compared with optimum cutting schedules generated by linear programming procedures. The latter can only be applied to aggregated stand data which cannot take into account individual stand characteristics important in cutting decisions.

Another project is analyzing procedures to set stand harvesting priorities for the aspen covertype which would achieve the highest degree of softwood production from the large softwood component of that covertype. Alternative harvest priorities already tested show substantially different softwood yields over time.

4. Analysis of timber investment opportunities

Specific covertypes, regions, and ownerships are being selected from the inventory data for analysis of potential economic returns of timber management. This research has concentrated on determining optimal economic rotations, potential for site conversion of off-site aspen and more intensive forms of management. The potential of wood as a source of energy in small power plants has also been analyzed (Rose and Olson 1979a, b).1/

5. Regional impact analysis

Once timber inventories have been analyzed in terms of physical and economic supplies, and long-term sustainable yields have been determined, it is feasible to develop regional scenarios to utilize available timber resources. For example, based on projection of the aspen covertype of unit 1 under various timber management intensities, we developed several regional scenarios including new industries such as waferboard and small power plants.2/

The potential regional impact of these new industries was analyzed via a regional input-output model developed by the Department of Agricultural Economics, University of Minnesota.

1/Aube, P. 1980. Cost analysis for a 25 megawatt wood-fueled power plant in Minnesota's inventory region 2. Unpublished M.S. thesis, College of Forestry, University of Minnesota.

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Shortcomings and Opportunities

No one knows the shortcomings of the forest survey better than those intimately involved with it, i.e., those who process and analyze it. It is clear that data processing has become an important time-consuming element of the forest survey. We now have computer programs that process thousands of records in seconds; however, it frequently takes weeks and months to set up such runs and similar time subsequently to assure that they are, in fact, correct computations. This setup and check time is a function of the complexity of the data set and the sampling design and there are a number of trade-offs that must be made in developing the actual design for any area. As the survey has evolved, especially in the last few years, numerous observations for variables other than timber have been added to the survey. The survey design in terms of field plot and processing costs has become a major factor in consideration of redesign. Costs of several hundred dollars per plot are not uncommon.

With such problems it is instructive to note that forest survey is going through a period of change where more and more variables are being suggested for inclusion and designers are seriously considering whether one survey can handle the entire task. We may find that separate surveys for timber, water, wildlife and aesthetic resources might be more efficient. In terms of analyses, the availability of the data through the System 2000 data base package, contemporary computer facilities, and projection models like STEMS or MFPS plus analysis programs like those developed by North Central and College resource analysis staff, offer many opportunities. Techniques for analysis are evolving and will become more penetrating as repeated observations become available and various approaches and their veracity can be verified.

The selected applications of survey data described here emphasize the importance of the availability of these data at frequent intervals. Ten or fewer year periods between surveys are critical if the data are to be truly effective for decision making. Data should further be collected for specific purposes which have been identified before the final design and execution of a survey. Since resource management decisions are the endpoint of any data collection endeavor, an examination of typical management decisions in forest resource management should provide an insight into basic data needs. The nature of the current sampling design and resulting plot data limit the use of the data to decision models at the regional planning level and largely rules out their use for decision making at the operational or field level. The latter decisions will require the location specific kinds of data which are currently collected by National Forests and the State DNR in their phase II inventories. It is important that regional survey efforts move to encompass such objectives and that greater speed and efficiency be added to all of the various inventory efforts.

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HOW FOREST INDUSTRY USES INVENTORY INFORMATION

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My participation in this conference is as a representative from the forest industry responding to the question of how the forest inventory data is used by industry. I will attempt to do so from two perspectives. The first will be in a general way from the industry's viewpoint and in some more specific details from Blandin's experience.

The needs by industry for an accurate and current inventory of its raw material resource is obvious. No business, large or small, can logically plan its operation without an inventory. When we speak of the forest industry, we are concerned with the third largest industry in Minnesota having a physical plant value in 1977 in excess of 468 million dollars for the pulp, paper and paper board portion of the industry. In addition, there is a very significant investment in physical plants for the solid wood industry. The total industry provides jobs for approximately 54,000 people. Blandin's last paper machine, put on line in 1975, cost approximately 50 million dollars. The planned expansion of our waferboard plant will be approximately 37.5 million dollars. St. Regis has just announced a 200 million dollar expansion at Sartell, Minnesota. These are examples of major and costly expansions and typical of the costs being incurred by the industry. We must be assured that the forest resource is available to assure their success.

I see the uses and needs for the forest inventory by the Minnesota industry to be as follows:

1. Industry needs to have accurate and current information on the amount of raw material available by species.

   We need this basic data to make a proper assessment of the resource. It will be up to us to make our own assessment of this information. We must decide the availability of resource to our own operations. The resource must be available in the quantities needed and at a price that can be justified to make a profit on the manufacture of the end product.

   With the possible exception of some smaller sawmills and some of the particle board plants, most forest industries in Minnesota are specific in their species requirements. Changing technology over time may change the proportions of a given species mix; but generally speaking, substituting one species for another is very difficult to accomplish in a short period of time. For this reason, the industry needs to have the resource information presented by forest types and species.

2. We must know the location of the resource.

   Location is and will continue to be a very critical factor in the resource considerations by industry. A study by the

American Pulpwood Association in *1974 indicated that it takes an average of 5.16 gallons of fuel to produce a cord of pulpwood from the stump to the mill. Of this amount, 2.61 gallons or 51% was for transportation. The availability and cost of energy for transportation will play an ever increasingly important role in the location of manufacturing plants in relation to the forest resource.

3. We must know the volume and condition of the resource by ownership.

With approximately 63% of the commercial forest land in Northern Minnesota in public ownership, it is very important to the industry that we know the resource base within each ownership and how it is being managed. With this knowledge, an assessment can be made of the management by the responsible public agencies. We can then reasonably respond to any problems this data might indicate. For instance, if the indicated annual allowable cut greatly exceeds the actual drain of the resource, it might point out a problem in sales and marketing by the public agency.

The same is true of the private nonindustrial segments of the commercial forest land ownership. Unless we know what the basic forest resource data indicates on those lands, it is very difficult for either industry, or for that matter the public agencies, to respond to problems relating to the management of nonindustrial forest land.

4. We must have an accurate and current assessment of the total drain on the resource.

Industry must have an accurate and current picture of the total drain on the forest resource including both commodity and noncommodity uses. We all realize that it is difficult to obtain some of this information, particularly the noncommodity type uses such as home fuel, nonmarketed lumber, etc.; but in order to get the total resource picture, it is essential that the volumes used be identified as accurately as is possible.

5. An accurate assessment of the forest condition is essential information.

This refers to the fact that we not only need inventory information to tell us how many trees are growing but we need to know how well they are growing. Nationwide, our forest lands are producing at about 50% of their potential rate. With an ever-dwindling commercial forest land base, we must increase the rate of growth on the remaining acres. Most of you are aware of the **Forest Productivity Project ini-

*American Pulpwood Association - Fuel Survey - 1974 Data.
**Minnesota Forest Productivity Report - 1979.

tiated by the Forest Industries Council to forestall a wood shortage that could occur in this nation by the year 2020 if measures are not taken to increase the productivity of our forests. The Minnesota study relating to this program indicates that by using the most apparent good forest management measures on the acres identified in the 1977 Minnesota Inventory as needing treatment, we could treat 4.5 million acres of commercial forestland for a resulting annual incremental yield of 213.8 million cubic feet of softwood and 58.7 million cubic feet of hardwood. The total cost of applying these management measures would be 535 million dollars.

This volume is four times the present consumption of softwood and is 70% above the current use of hardwood. By beginning such a program now, the incremental increase would begin coming on stream at about the time required to avert any potential shortage of wood in Minnesota.

6. We need an assessment by responsible public agencies of the implications of the forest inventory.

Although it was mentioned that industry must apply its own criteria to the basic inventory information, it is also essential that the responsible public agencies explain the implications resulting from the inventory information. For instance, the annual allowable cut information that has been discussed is from all ownerships and all types without regard to availability. This information can be very misleading unless the factors affecting availability are carefully analyzed and the material is presented in such a way as to recognize deductions to the total annual allowable harvest information. The confidence level of annual allowable information could be greatly enhanced by identifying the computations used to determine it. Factors such as rotation age, volumes per acre, growth rates and other critical criteria should be identified so that those using the information will have a basis of comparison with their own criteria.

7. We need to continually update and renew the forest inventory.

The last point I would like to make on the needs of a forest inventory by the industry relates to the timing. Fifteen years between inventories is, in my estimation, too long. Admittedly, with computerized models we now have better tools with which to update the inventory information, but a physical inventory should be made every ten years or less to keep an accurate handle on the resource.

We also feel that some method should be found to shorten the length of time between the completion of the fieldwork and the publication of the resource data.

Good current resource inventory information is absolutely essential when the industry is confronted by the political implications of forest resource management. The 1962 inventory

> data was completely ineffectual in proving the point that the industry tried to make in the BWCA controversy, that the softwood species were not available outside that area being locked up in wilderness. The 1977 inventory has proven the point but too late to be effective except in an intensified softwood management posture.
>
> The industry and the public can ill afford the political decisions based on old or unreliable data or misinterpretations of data which significantly affect the role of our forest resources and their place in the economy.

In order to respond to the specific uses of forest inventory information, I would like to give a brief background report on the formation and expansion of the Blandin operation.

Blandin Paper Company had its beginning with the Itasca Paper Company as a newsprint producer in 1901. The first mill produced about 25 tons of paper a day and cost approximately $230,000.00 to construct.

In 1923 a second newsprint machine was added bringing total production to 75 tons per day.

During the early 1930's it was clear that the large modern Canadian newsprint mills were going to make the Blandin mill obsolete, so the company installed a new machine capable of producing 100 tons of paper per day. In 1935 the mill began switching some of their production to groundwood specialty papers.

In 1946 newsprint production was eliminated entirely, and in 1955 a trailing blade coater was installed giving birth to the coated publication paper our mill now produces.

The next large expansion of the paper mill was completed in 1963 increasing production to 131,000 tons per year and providing jobs for 640 people.

By 1969, through modifications and rebuilds to existing equipment, production had increased to 188,000 tons and employment had reached 844 people.

I believe that it is true that to this point in the company's growth pattern, the major considerations for expanded operations were available markets and capital formation. The 1962 forest inventory indicated excess volumes of all species required.

In the early 1970's it became evident that market conditions would support another expansion of paper production. It was also known from the examination and analysis of resource inventory information that a large surplus of maturing aspen existed and that the harvest of this aspen resource would "free up" additional softwoods which could be used for a paper mill expansion.

The decision was made in 1970 to construct a building board plant to utilize the aspen resource. In 1972 this first waferboard plant in the

country was completed at a cost of about 15 million dollars. This was followed by the largest expansion ever undertaken by the paper mill. Number 5 machine was put on stream in 1975 at a cost of approximately 50 million dollars. This brought our total production at the paper mill to over 308,000 tons per year with more than 1,100 people employed.

Indications of a greatly expanded market for building board led to the decision to expand the present manufacturing plant, and Blandin Wood Products Company is now embarked on a 37.5 million dollar expansion project with completion scheduled for mid 1981. This expansion will eventually triple the wood resource required at that facility.

We have reached the time in the growth of the forest industry in Minnesota when the available resource has become a very critical consideration when planning for new or expanded operations. If the demand for wood exceeds the supply, then only those industries capable of competing for the existing supply will survive.

New technology has allowed for some change in the species mix in the production of our paper. Blandin has gone from being a mill using primarily spruce groundwood to a point in time when we are currently using only 22% spruce, 23% balsam and the balance of 55% hardwood, primarily aspen. We also feel that through research and development, we will be able to utilize many of the hardwoods in addition to the aspen in our wafer board plant.

Present wood usage at both mills is 188,000 cords - 17% spruce, 18% balsam and 65% hardwoods. With the additional 140,000 cords of hardwood to be used eventually at Blandin Wood Products Company, our total corporate use of wood will be 79% hardwood and 21% softwood with the softwood component split fairly equally between spruce and balsam.

If we consider the growing-stock volume of the softwood and hardwood species that we will be using in our mills in the Northern Aspen - Birch Unit I and the Northern Pine Unit II, which are our mills' major wood sources, we find about a 75% hardwood - 25% softwood ratio. This indicates to our management that our usage of species is consistent with the resource our forest presently is growing.

From our examination of the resource data, we are convinced that the resource base is adequate for Blandin's present expansion and that we will be able to successfully compete for that resource. Our use of the resource inventory data is now directed toward identifying the logistical advantage for our mills' procurement program.

In summary, the forest industry is continually in need of the best and most current resource information available. Our future plans and programs are greatly influenced by the results of the forest inventory process.

We depend upon the public agencies and those in the academic field to analyze and distribute the results of the inventory in a clear, concise and unbiased fashion to all segments of society. Our use of the forest inventory information may be primarily directed toward utilization while

Others may be more interested in some other use aspect of the forest. In discussion of these sometimes conflicting uses of the forest, we should be able to find common ground from which to begin discussion in the forest resource information data.

Only by the continual updating and renewal of the Forest Resource Information can measurement be made of past management policies and practices and progress made toward improving them.

HOW ENVIRONMENTAL GROUPS USE INVENTORY INFORMATION

Wesley Libbey
Izaak Walton League
Grand Rapids, Minnesota

The primary use of inventory information is in analyzing resource problems and reaching conclusions which permit taking positions that are in the long term public interest. The better the data, the more likely it is that decisions based on the data will be useful and productive.

Forest inventory data will be one of the decisive factors in reaching a position on those forest related programs of the Congress, State Legislatures, public agencies or private enterprise dealing with land use or forestry practices and management.

Taking stock is the very first step in operating a business. It is fundamental to know what you have before you can make a plan of operation. A good inventory should be the beginning cornerstone of a good forestry program. It is my experience that we lack a good forest inventory. I hear public foresters say we have an adequate supply of trees and I hear industry foresters say they can't find them. An adequate forest inventory should be both comprehensive enough and detailed enough that it can supply answers to everyone's questions. I don't like being placed in the middle, having to make a decision about who is correct. Industry is entitled to know what wood supplies are available to enable them to produce the items we all need as consumers. And the wood-growing forester has the right to know the condition of his growing stock. Environmentalists should be able to feel that a position they take is based on a sound inventory. An inventory is a statement of fact--it should not be subject to question or various interpretations.

It seems to me that infrequent and inadequate inventories have been an outgrowth of a basic problem in forestry--lack of adequate funding and manpower. State legislatures and the Congress have historically regarded forests as a source of income, rather than as a resource which requires investment to produce a much greater return. This has resulted in concern about shortages of timber, which in turn, gives rise to many land-use controversies. Foresters know how to greatly increase forest growth given the funds and manpower required. If forestry programs had been adequately funded over the past fifty years, we would have timber running out of our ears and would not be having land-use conflicts about wilderness, parks, recreation, etc.. And yet today, we are still trying to accomplish the very first basic step--an adequate, acceptable inventory.

Investment in production of natural resources is a basic way to control inflation. An abundant timber supply would reduce the cost of housing. Most long-range planning in our nation extends out about four years -- from one presidential election to the next. By contrast, investment in forests needs to cover fifty to one hundred years. An adequate investment in forest management over the years will help to reduce inflation, improve the balance of payments and return a profit to finance future good management of the forest resource.

I would also like to point out the need for information by environmental groups, not only from an adequate forest inventory, but also for the need to update this information periodically. Up to now we have had to rely on inventory data released about 1962. Many environmental decisions have been required during this long period of increasingly out-of-date information. Environmental decisions require many different types of data. An inventory should be detailed enough to provide the variety of answers environmental groups need. They also need to have inventory data interpreted and analyzed. And they would find very useful, projections based on present data that could be made available between inventories. Inventory data from various land ownerships should be assembled on a statewide basis and also evaluated on a statewide basis. All these are necessary to environmental groups in reaching sound decisions.

In Summary

1. Environmental groups repeatedly make decisions based on forest inventory data.

2. An inventory is a basic first requirement.

3. The inventory should be comprehensive and detailed enough to answer all questions.

4. Inventories should be periodic and updated frequently.

5. Adequate funding of forest inventory and management is in the long term public interest.

6. Environmental groups need inventory evaluation, both detailed and statewide, and projections between inventories.

HOW THE NATIONAL FORESTS USE INVENTORY INFORMATION

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Cass Lake, Minnesota

Most organizations have many sources of information with which to work. The National Forests in Minnesota have long depended upon the Forest Survey effort as one of these sources.

At present, there are two very specific pieces of data that come to us solely from the survey. One of these is growth, the other total volume. Both of these items come from a series of permanent plots installed on the Forests which are remeasured each time a survey is conducted.

While both National Forests in Minnesota are operating under area control and, primarily, even-age management, growth data is important as a sounding board against which cut volume can be compared to insure we are not cutting more than we are growing.

Growth data is also a key ingredient in many automated models being used today to simulate the long range business of forest management.

Obviously, the better the growth data, the better and more acurate the projections will be.

Total volume is a figure that probably generates more interest outside the National Forests than internally. Forest industry particularly needs to know what the total available "woodpile" is. We regularly use Forest Survey total volume figures in response to external inquiries.

The expansion in the wood-using industry in northern Minnesota bears witness to the magnitude of the decisions that may be made on the weight of such data.

Total volume data is also used as a check on progress made towards certain management objectives. For example, if management has the objective of increasing the jack pine component on the forest; one has but to study the volume figures from one survey report to the next to see how things are coming along. If it hasn't increased, something might be wrong.

As we do our long range planning, other types of Forest Survey data are also useful to us. Information regarding trends and utilization is very helpful in making long range demand projections. One of the products the National Forests produce is raw material for the wood-using industry. By knowing what the trend is in commercial forest land over all ownerships; we can better gauge the importance of our role as a stabilizing influence in local situations.

Trends in certain timber types or age classes are indicators of what might be reasons for trends in other resources. Potential problems can be identified and corrective action taken if related trends are studied. As an example, if a high priority objective is increasing the ruffed grouse population, and you see a downward trend in the aspen type--watch out!

Utilization data is of key importance to a raw material producer. In the long range business of forest management, an answer to the question "how much of what shall we produce?" is difficult to come by, and I might add, the source of much discussion among foresters and forest managers. Forest Survey data regarding utilization helps us formulate alternative answers to that question by providing good information on what's being used and where it's being used.

To more fully understand the use of inventory data by the National Forests, it might be helpful to know something of our internal needs and the methods we use to satisfy those needs. Land classification provides an illustration. The decision to classify forest land as commercial forest land, or something else (productive reserved for example) is to decide whether or not wood products from it are available as a commodity.

The Forest Survey before you tells us that there are nearly 14 million acres of commercial forest land in the State. The Chippewa National Forest contains 562,000 of those acres. In using that figure on the Chippewa, it must be broken down into our own sub categories. We recognize 13 sub categories of commercial forest land. Each one carries with it certain policies and coordination rquirements that directly affect the management activities on that piece of land, and the available volume that can be planned to come from it. The method we use to get this type of site-specific data is called compartment examination. One of the outputs of this examination is a stand-by-stand identification of land use class.

Another example can be found in the figures on area by timber type. There are 5.3 million acres of aspen type in the State. The National Forests contain 598 thousand acres of the aspen type. The Chippewa National Forest contains 207,000 of those acres--someplace! In order to plan ahead for timber sales, we must know exactly where those acres are.

Again, compartment examination provides the answer on a stand-by-stand basis.

The point being made is evident. The more intensely an organization manages its land, the more specificity is required in the data. On the National Forests, Forest Survey data provides the foundation from which land management planning begins. Our internal systems refine that data to the level of site-specific projects such as timber sales.

How many times did you hear the word PLANNING during this conference?

Planning has become one of the key words in the natural resource manager's vocabulary. Managers of the National Forests are acutely aware of the value of sound data upon which sound plans must be based. In all likelihood, we will continue to depend on the Forest Survey as one of our sources of this data.

HOW FOREST RESOURCE CONSULTANTS USE INVENTORY INFORMATION

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George Banzhaf & Company
Forest Resource Consultants
Milwaukee, Wisconsin

Introduction

I am certain that the Minnesota Forest Resource Inventory Conference will help to promote a better understanding of the importance of inventory information, the present usage for these data, as well as the future needs of various user groups. I am hopeful that conferences of this sort will be repeated in other states when their new survey information becomes available.

Inventory systems and information are the foundation for sound and efficient management decisions regarding any commodity, whether it be nuts and bolts in a hardware store or trees in a forest. You must know what you have before you can determine what should be done with what you have.

As a forest resource consulting firm, George Banzhaf & Company, serves those involved in the use of forest resources by providing an independent and, hopefully objective, point of view in the management of those resources. Although we have worked on occasion with the small landowner sector, our primary client base is the organization involved in the management of large tracts of timberland. In the private sector this includes, primarily, the forest industry. In the public sector, state and federal land management agencies, as well as regional and state planning commissions, are the prime users of our services.

Our involvement with forest survey information as published by the USDA Forest Service ranges from the installation of field inventory plots to the analysis of data on a unit or regional basis.

Resource Analyses

The types of analyses we perform with inventory data can be

delineated into two basic categories:

1. State or regional supply studies for land use planning and development.

2. Feasibility studies involving the location of a new forest products converting plant or the expansion of an existing facility.

The regional or state planning agency normally wants to obtain a better understanding of the economic development potential of the resources within the region. This client also is concerned with providing a balance of economic development with the allocation of resources to meet the needs and desires of the citizenry. This would include forest products production, recreation opportunities, and wilderness preservation.

The client from the industrial sector is primarily concerned with determining whether there is sufficient wood supply to justify expansion or location of a new converting facility. This is, indeed, a critical factor. No matter what forest products facility is planned, it is no better than its wood supply. Because investments range from $500,000 for some sawmills to as much as $1,000,000,000 for a large paper mill, forest survey or inventory data had better be accurate as well as understandable.

Whether it be for a regional land use planning study or a mill location study, there is certain information which we find of particular value in gaining an understanding of forest resources and their availability for development. They are the following:

Data or Inventory Component	Study Use or Value
1. Area by land classification.	This component is helpful in determining land use patterns and changes.
2. Area by site.	This gives an indication of the productive capacity of a region.
3. Area and volume by ownership classification	This component is helpful in determining the availability of the forest resource as reflected by assumptions on differing landowner management objectives.
4. Area and volume by species and forest type	This is valuable in determining whether or not

Data or Inventory Component	Study Use or Value
	specific wood supply needs can be met both in terms of volume as well as general level of concentration.
5. Volume by product and diameter classification	It is important to be able to view the timber resource in terms of the volume of the material that can be economically utilized by the client you are serving.
6. Volume by stand-age class	This information is important in determining whether or not the age class distribution is out of balance. In those cases where excessive volume is in the older age classes, initial harvesting activities over and above annual growth would be required
7. Growth and removal or drain data	This information will be of assistance in determining the sustained yield capacity of the region as well as indicating that portion of the sustained yield capacity which is currently being used.

Data Limitations

In obtaining a true understanding of the value of this information it is equally important to understand the limitations of survey data.

Forest Survey data are generated through a light statistical sample. The sampling procedures result in excellent statistical reliability when the data are used for a State as a whole or for a specific survey region (for example, Aspen -- Birch unit of Northeast Minnesota). Unfortunately, this information is misused when localization to the County level is attempted. County information is available and, in terms of overall acreage and volume, is relatively reliable. Specific volume data by species, however, are simply not statistically meaningful. These data should only be used as general indicators and not as definitive answers.

In addition, it is important to understand that the Forest Survey deals, primarily, with biological or physical availability. It does not deal with economic availability. Although some indication of economic availability can be gained through an understanding of volume per acre, the matter of physical access is an important component not included in survey information. Forest Survey information should be considered as an excellent regional planning tool -- no more!

Future Survey Needs for the Consulting Firm

It is my opinion that increased accessibility to the raw field data or plot data would be extremely helpful to consulting firms. This would enable the private sector to have the flexibility to compile their own tables for their own purposes. I am fully aware that any data or information so created could not have the approval or certification as to its accuracy by the Experiment Station. Nevertheless, expertise in this field is no longer limited to the Experiment Station or the University level. It is my understanding that there is a data retrieval system currently being developed which should be available in the near future.

With increasing pressure for up-to-date land use and resource information, it is imperative that survey remeasurements keep on schedule and are supplemented through the use of projection models to generate up-to-date information.

Closing Comments

I have attempted to show how very necessary and useful forest inventory information is to the consultant. The system, when maintained and not allowed to become out of date, can provide an excellent regional planning tool. This information is critical to the effective management of our forest resources.

* * *

HOW REGIONAL PLANNERS USE INVENTORY INFORMATION

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Duluth, Minnesota

Introduction

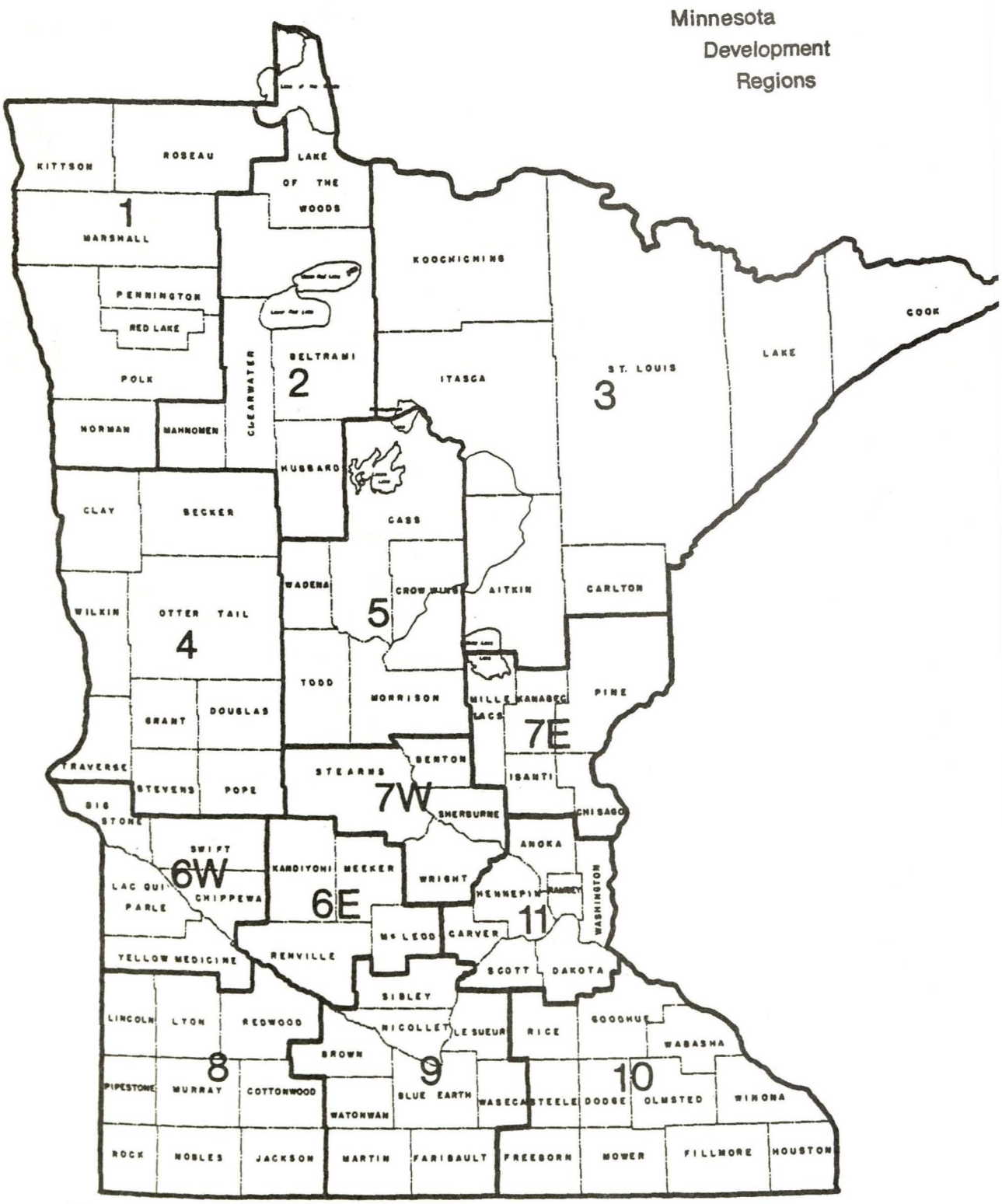
This discussion will focus on three general areas. First for the benefit of those who are not familiar with sub-state government organization in Minnesota, I will describe the Regional Development Commission structure in the state and provide a general history and background of the Arrowhead Regional Development Commission (ARDC). Second, I would like to describe involvement by the ARDC in Forestry Planning and Forestry Management relative to the use of inventory data and other research information developed by the North Central Forest Experiment Station (NCFES). Third, I would like to comment on future concerns with forest inventory information and NCFES research in general.

Minnesota Regional Development Commission History and the Arrowhead Regional Development Commission

The thirteen Regional Development Commissions that exist in Minnesota today were made possible through the Minnesota Regional Development Act of 1969. This legislation established the structure and role for Commissions. The broad purpose for Regional Commissions in Minnesota according to the 1969 Act is to "facilitate intergovernmental cooperation and to insure the orderly and harmonious coordination of state, federal, and local comprehensive planning and development programs for the solution of economic, social, physical, governmental problems of the state and its citizens." The legislation also provides authority for Regional Commissions to receive state and federal grants for regional purposes, to conduct broad planning on a multi-governmental and individual government basis, and to conduct comprehensive planning for the overall geographic area within their jurisdiction. In addition, Commissions are empowered to review the plans of local government units, to review long-term comprehensive plans of other independent agencies within the region if such plans are determined to have a regional or a multi-governmental effect, and to review all applications for state and federal aid programs.

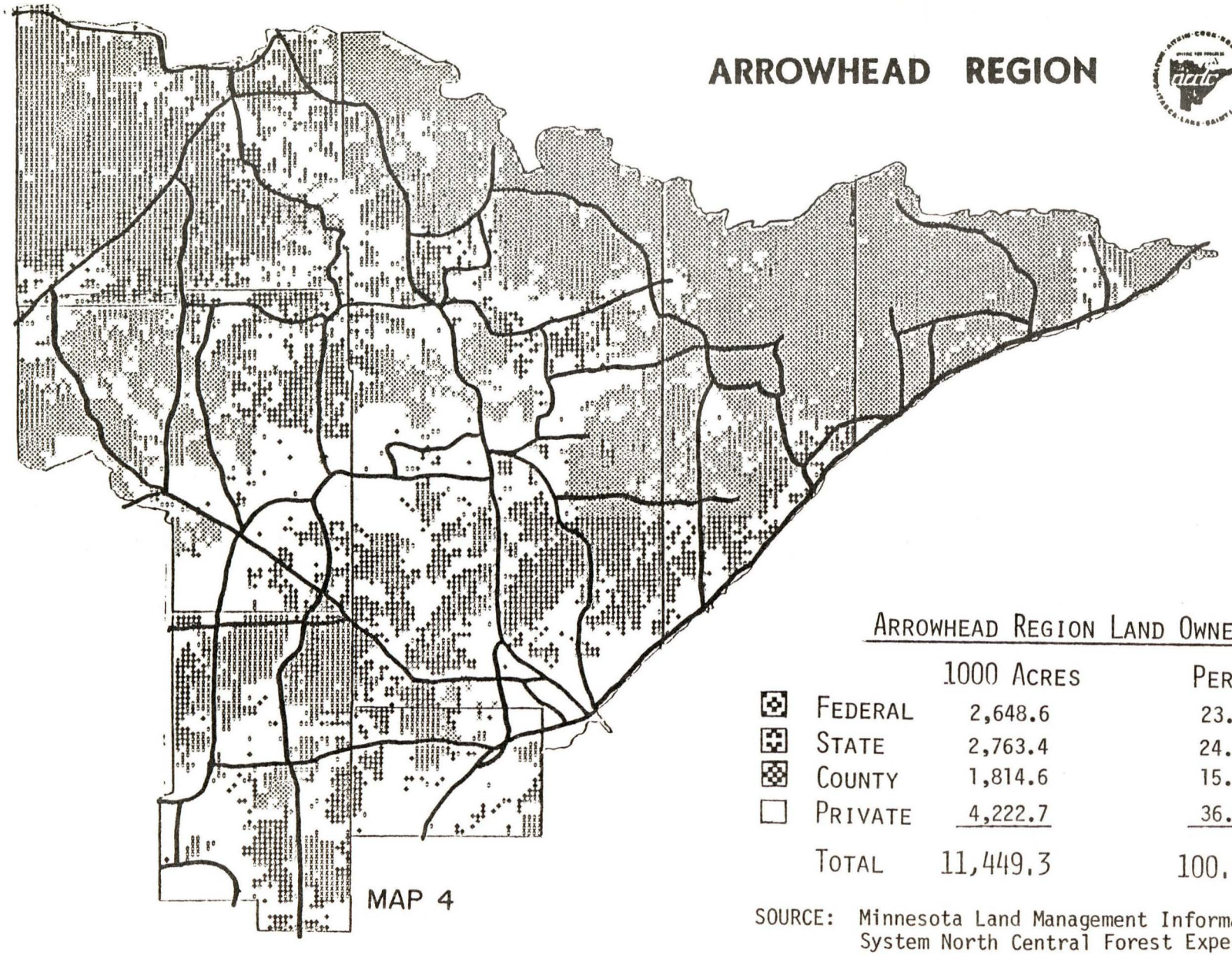
The ARDC was one of the first organizations of this type formed in the State of Minnesota. Because the Arrowhead Region had been an Economic Development District of the U.S. Department of Commerce, Economic Development Administration since 1967, the administrative structure and regional focus of the Development District made it an easy task for the agency to adopt the expanded Regional Commission role allowed by state legislation.

Figure 1


Minnesota
Development
Regions
KITTSON
ROSEAU
LAKE OF THE WOODS
1
MARSHALL
PENNINGTON
RED LAKE
POLK
CLEARWATER
BELTRAMI
2
KOOCHICHING
ITASCA
3
ST. LOUIS
LAKE
COOK
NORMAN
MAHNOMEN
HUBBARD
CASS
CLAY
BECKER
WILKIN
OTTER TAIL
4
WADENA
CROW WING
5
AITKIN
CARLTON
TODD
MORRISON
MILLE LACS
KANABEC
PINE
7E
GRANT
DOUGLAS
TRAVERSE
STEVENS
POPE
STEARNS
BENTON
7W
ISANTI
CHISAGO
BIG STONE
SHERBURNE
SWIFT
6W
KANDIYOHI
MEEKER
WRIGHT
ANOKA
LAC QUI PARLE
CHIPPEWA
6E
HENNEPIN
RAMSEY
11
WASHINGTON
McLEOD
CARVER
YELLOW MEDICINE
RENVILLE
SCOTT
DAKOTA
SIBLEY
LINCOLN
LYON
REDWOOD
NICOLLET
LE SUEUR
RICE
GOODHUE
WABASHA
BROWN
8
9
10
PIPESTONE
MURRAY
COTTONWOOD
BLUE EARTH
WASECA
STEELE
DODGE
OLMSTED
WINONA
WATONWAN
ROCK
NOBLES
JACKSON
MARTIN
FARIBAULT
FREEBORN
MOWER
FILLMORE
HOUSTON

56

Figure 2



ARROWHEAD REGION LAND OWNERSHIP

	1000 ACRES	PERCENT
FEDERAL	2,648.6	23.1
STATE	2,763.4	24.1
COUNTY	1,814.6	15.9
PRIVATE	4,222.7	36.9
TOTAL	11,449.3	100.0%

SOURCE: Minnesota Land Management Information System North Central Forest Experiment State

A brief background of the Arrowhead Region will help provide reason to our agency's belief that a good forest inventory information base is necessary to good resource management in Minnesota. The Arrowhead Region encompasses seven counties in Northeastern Minnesota. In area, the region includes almost 20,000 square miles which is roughly one quarter of the state's total land area. The region is 80 per cent forested and contains slightly more than half of Minnesota's commercial forest land according to the 1977 forest survey. The amount of human resources in the Arrowhead Region contrast with its abundant natural resources; in 1970 the population was 337,000 or about 8.5 per cent of the total Minnesota population at that time.

The organizational structure of the ARDC includes a Commission of 53 members, a Board of Directors of 13 members and a number of Advisory Committees. The Commission is the policy making body of the organization and currently meets four times a year. The Board of Directors meets monthly and is charged with managing the affairs and the policies of the Commission. The agency has 12 functioning Advisory Committees. These Committees have their own operating by-laws, are supported by ARDC staff, and play an important role in developing ARDC policy. Policy statements or policy positions that are developed by Advisory Committees are forwarded to the Directors and Commission for approval prior to transmittal to governmental agencies and funding sources.

ARDC and Forestry

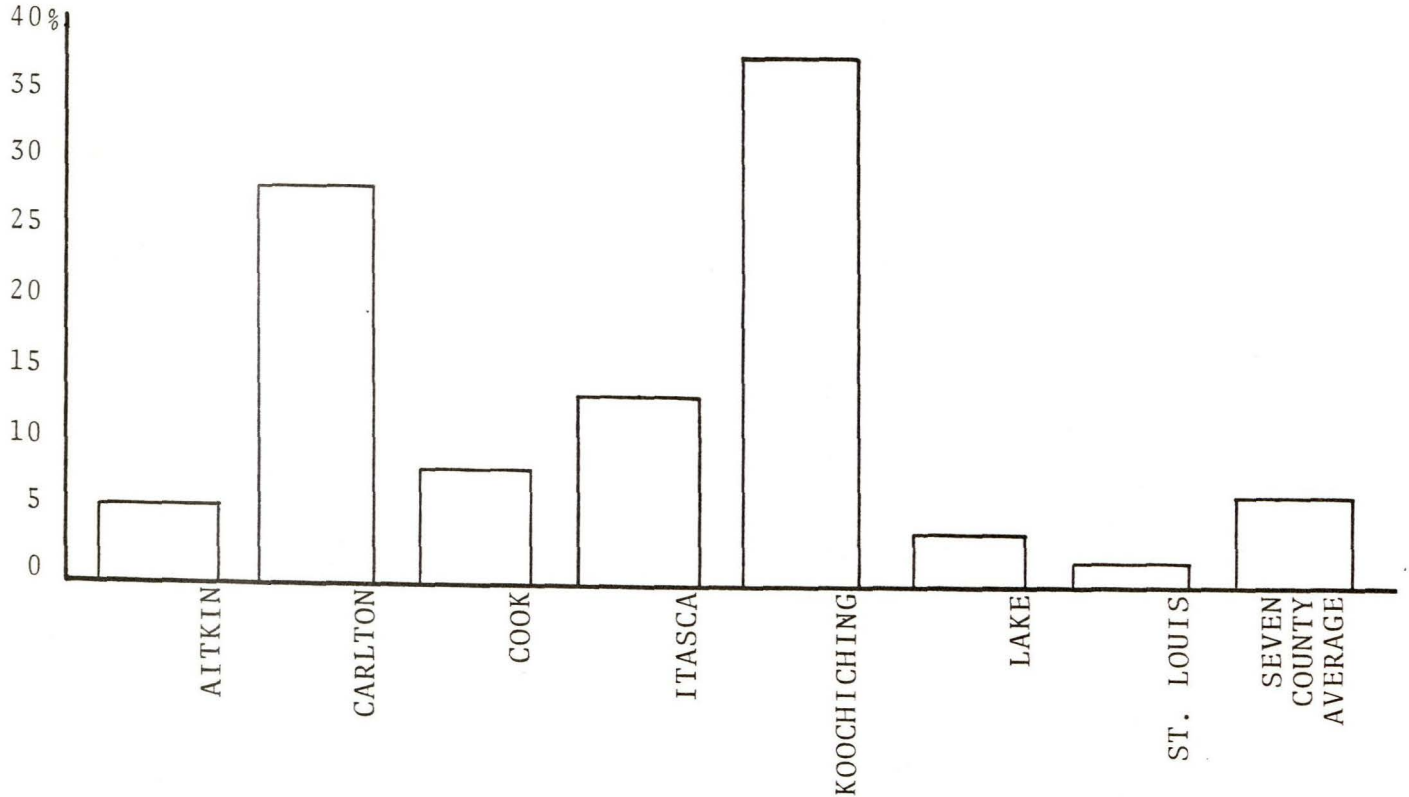
The forest resource in the seven county Arrowhead Region plays an important role in the region's economy. In 1975, two of the seven Arrowhead counties had more than 25 per cent of the labor forest engaged in the primary wood processing industry. (Myers, Kallio, and Friest, 1977).

(Figure 3, Per cent of Labor Forest Engage in Primary Wood Processing in the Arrowhead Region, 1975)

Formal involvement in forestry by the ARDC began in 1973. In January of that year, Raymond O. Benton (Forester, Division of State and Private Forestry, USDA Forest Service) reported to the ARDC for a one-year work assignment with the agency. As a result of Mr. Benton's involvement with the agency, in February of 1974 the ARDC Board of Directors authorized the formation of a Forestry Advisory Committee to assist the Commission with formulating policies on timber resources and land management within the region. This Committee has been very active since its inception in guiding ARDC planners and the agency's Board and Commission in policy matters on Forestry in Northeastern Minnesota. The Committee has broad representation from government, private forest industry and citizens within the Arrowhead Region. Essentially all government agencies that have forest management responsibilities within the region are represented on the ARDC Forestry Committee.

Another significant result of Mr. Benton's work at ARDC was a report that described the forestry resources within the seven county Arrowhead Region based on 1962 NCFES inventory data. This report (1974 Arrowhead Timber Resources) served as a problem analysis and policy guide for the Arrowhead

FIGURE 3
PERCENT OF LABOR FORCE ENGAGED IN PRIMARY WOOD PROCESSING IN THE ARROWHEAD REGION. 1975



Commission and Board of Directors. The report also identified some opportunities and constraints for utilization of the timber resource of the region.

There have been additional forestry activities by the ARDC which involved timber inventory in Minnesota. The ARDC worked at both the state and federal levels to obtain funding for the 1977 Forest Inventory in Minnesota Staff of the ARDC were involved in coding the vegetative cover type information for the seven county Arrowhead Region which is represented on the statewide forest cover map that was published by the Minnesota State Planning Agency and NCFES.

Also, a cooperative project between the ARDC, the Minnesota Department of Natural Resources, and the Division of State and Private Forestry (USDA Forest Service) resulted in a publication that relied heavily on NCFES research and forest inventory information. Some of the findings in the publication (1978 Arrowhead Timber Resources Report) are highlighted here.

The purpose of the 1978 Arrowhead Timber Resources Report was to quantify and qualify the timber resource within the seven county region. Quantification of the timber resource was based on preliminary timber inventory data for Minnesota Forestry Survey Units 1 and 2 that was provided by the NCFES. This information was used to describe the supply of timber resources within the region. (Note: The contract period of ARDC involvement in the 1978 study did not allow the option of waiting until the final resource documents on the 1977 Timber Resource Report were prepared and distributed to the public. Therefore, the statistics included in the 1978 Arrowhead Timber Resources document should be revised to reflect the withdrawal of timber and commercial forest land that resulted from the 1978 Federal BWCA legislation; P.L. 95-495).

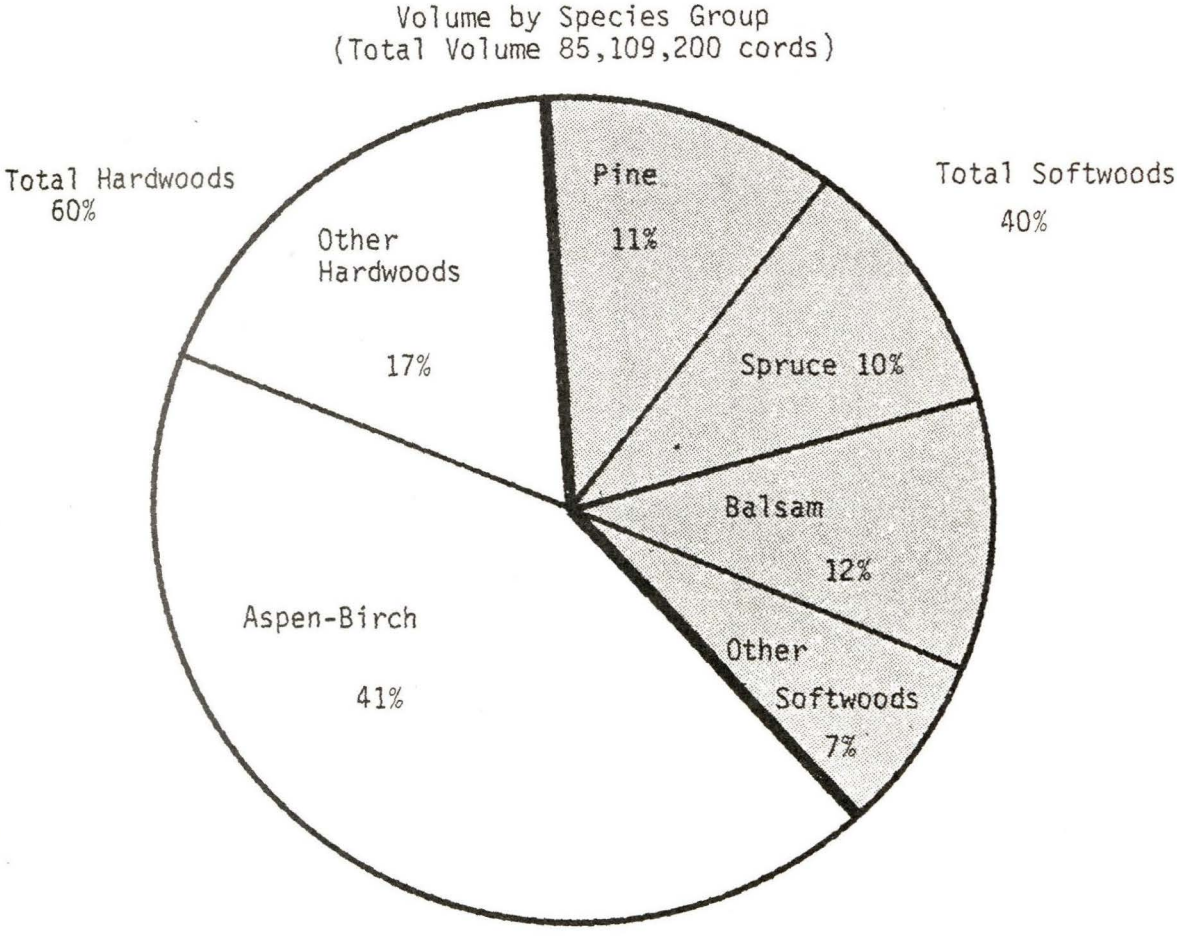
(Figure 4, Arrowhead Region Timber Volume by Species Group, 1977)
(Figure 5, Arrowhead Region Commercial Forest Land by Ownership, 1977)

For historical perspective, between timber inventory dates of 1953-1962 the Arrowhead Region experienced a decline in commercial forest acreage of less than 1 per cent overall. In contrast with this earlier period, between 1962 and 1977 there was a reduction in commercial forest land within the region that exceeded 1 per cent annually. On a species basis there was an approximate 700,000 acre decline within the softwood type alone. The most sought after softwood species (Black Spruce and Jackpine) accounted for more than 400,000 acres of this softwood type reduction. However, there was increase in the 1962-1977 period in the hardwood type in excess of 120,000 acres.

The 1978 Arrowhead Timber Resources Report also evaluated various species components of the region's timber resource. Within both Aspen and Birch in the Arrowhead Region there is a significant portion of the resource in the 40-70 year class.

(Figure 6, Overall Volume by Age Class in the Aspen and Birch Species Within the Arrowhead Region)

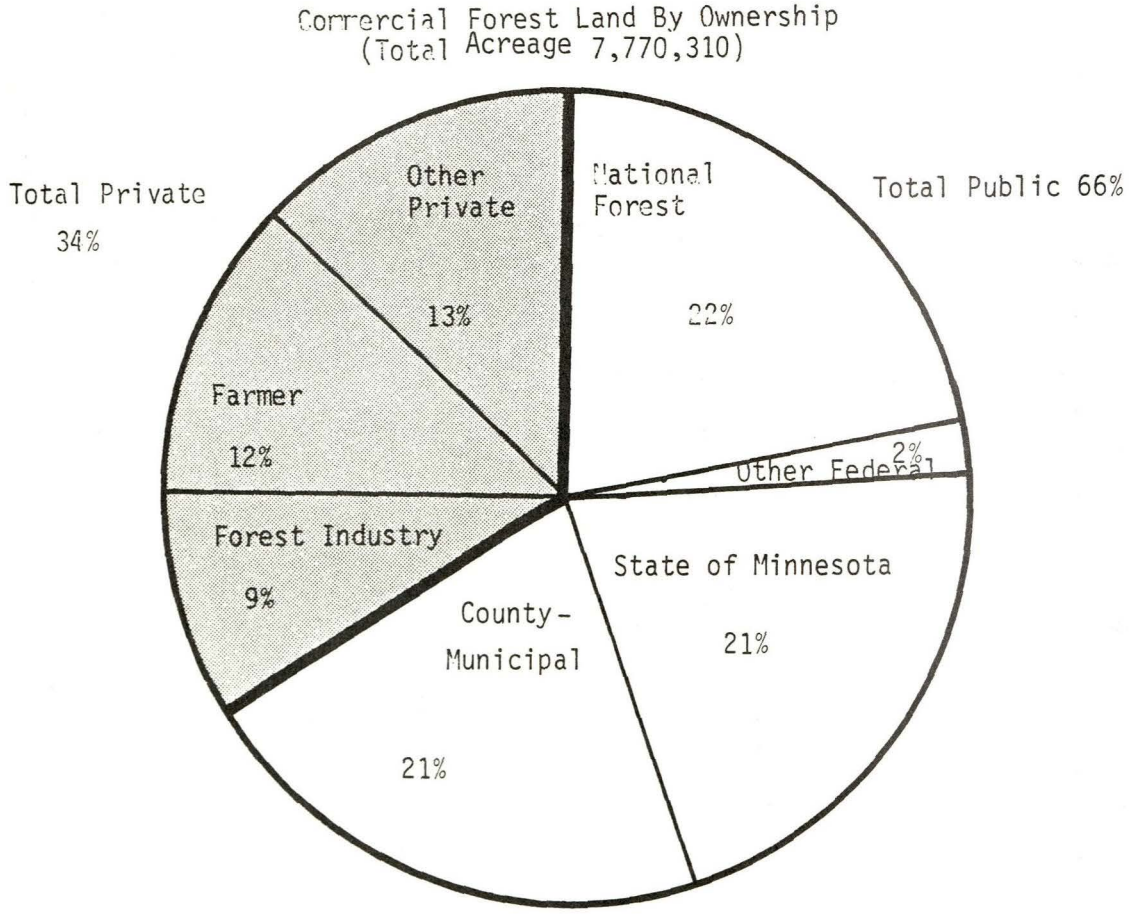
Figure 4



Source: North Central Forest Experiment Station, St. Paul, Minnesota

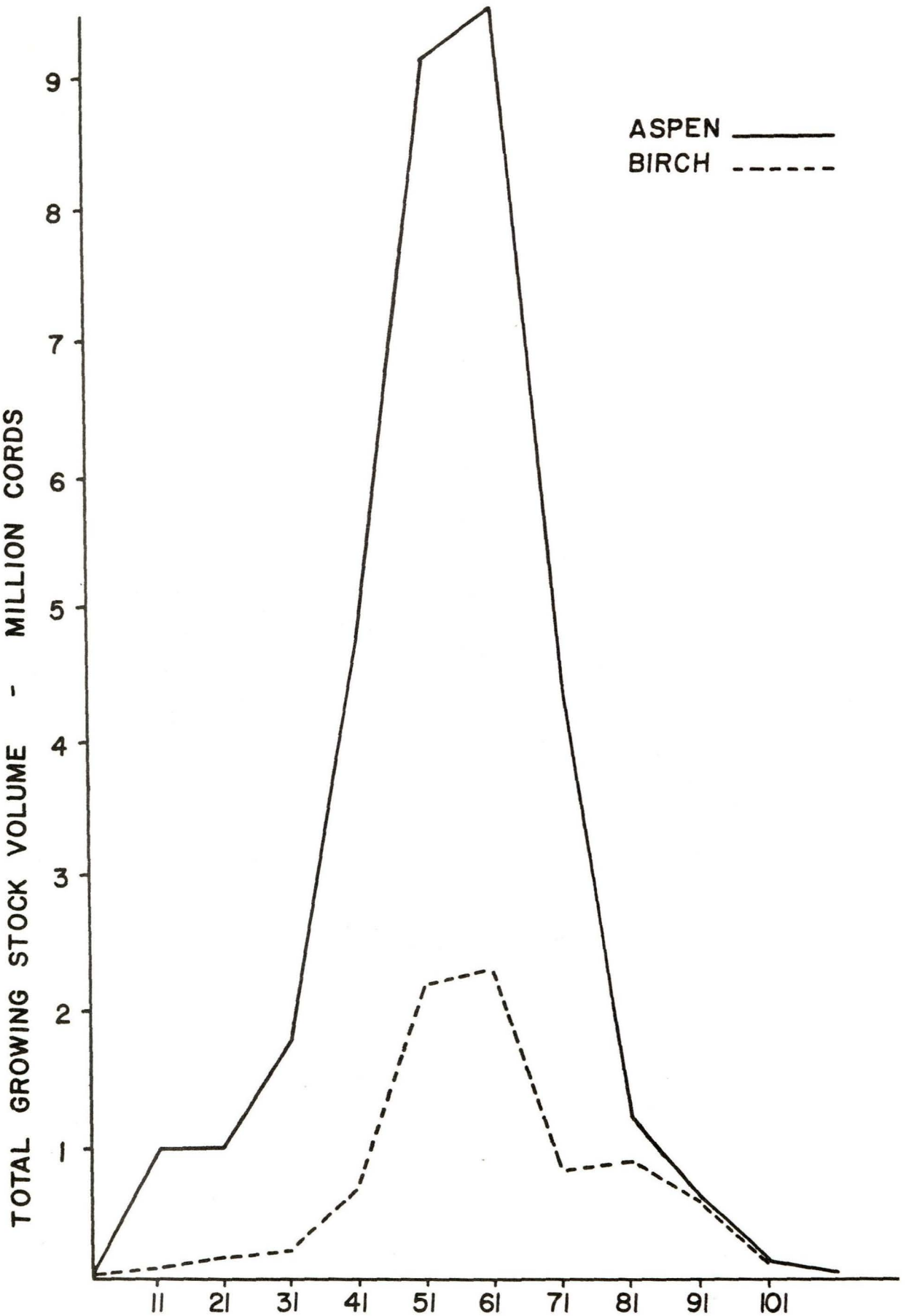
Figure 5

SOURCE: NCFES



Source: North Central Forest Experiment Station, St. Paul, Minnesota

FIGURE 6 VOLUME BY AGE CLASS



Our effort to qualify the timber resource within the Arrowhead Region involved an analysis of potential impacts of various governmental programs that could result in withdrawals of timber acreage from productive use within the region. Programs that were evaluated and which had some real potential at the time of the study for affecting future productive use of the timber resource were the Federal Costal Zone Management Program (National Oceanographic and Atmospheric Administration), the U.S. Forest Service RARE II Program (Roadless Area Review and Evaluation Program II), the then pending federal legislation relating to the Boundary Waters Canoe Area (BWCA), and other federal and state programs.

In addition to evaluating possible withdrawals of timber acreage in the region we were interested in qualifying the Arrowhead Region's timber resource based on accessibility and transport costs. To accomplish this we applied a transportation model that was developed at the NCFES in 1972. Bradley (1972). This transportation model (ACCESS) was applied to evaluate the distribution and cost factors associated with transportation of timber resources for various different destinations or mill points.

(Figure 7, ACCESS Measurements for Forest Survey Plots in the Arrowhead Region)
(Figure 8, Hauling Costs for Minnesota Pulpwood by Road Quality and Truck Size, All Products (in dollars per/mile)

Our ACCESS analysis involved measuring the distance from forest survey plots within the Arrrowhead Region to eight different destinations. The distance from the forest survey plot to the destination by various haul road classes was recorded and incorporated into the data for use in the model. The table showing "dollars per cord mile allowances" (See Figure 8) were obtained from U.S. Forest Service, Timber Sale Handbook for Region 9. The hauling equipment options were essentially based on hauling capacity and truck size. Inputs necessary to use this model were 1) computer cards containing road distance measurements for individual plots, 2) a computer tape with forest inventory data for the forest survey plots for the region, and 3) the access computer program. The two examples of tables contained in the report that were produced by the ACCESS model are included in this discussion. Both tables describe the aspen timber resource within the counties of Itasca, Lake, and St. Louis for a Virginia, Minnesota mill site. The first table (See Figure 9) describes the different species that occur within the aspen type. The ACCESS tables provides this information by distance class relative to the destination and also provides a volume-weighted transportation costs according to various truck-trailer combinations (called options on the table). The second table (Figure10) summarizes the distribution of the total aspen species within all timber types relative to the Virginia, Minnesota mill site. Also generated on this table are the volume weighted transportation costs for hauling the aspen resource to the Virginia mill site within each distribution class.

(Figure 9, Distribution of Species Within the Aspen Timber Type Relative to the Virginia, Minnesota Mill Site)
(Figure10, Distribution of Total Aspen Species by Cover Type for Itasca, Lake, and St. Louis Counties Relative to Virginia, Minnesota Mill Site)
(Figure 11, Mill Site; Virginia, Includes Cook, Lake and St. Louis Counties Distribution of Growing Stock Volume by Distance From Mill Site)

Figure 7

ACCESS MEASUREMENTS FOR SURVEY PLOTS IN THE ARROWHEAD REGION

Destination	County Inventory
1. Cloquet	Aitkin Carlton Itasca Lake St. Louis
2. Duluth	Aitkin Carlton Itasca Lake St. Louis
3. Grand Marais	Cook Lake
4. Grand Rapids	Aitkin Carlton Itasca Koochiching St. Louis
5. Internation Falls	Itasca Koochiching St. Louis
6. Isabella	Cook Lake
7. Two Harbors	Cook Lake St. Louis
8. Virginia	Itasca Lake St. Louis

Figure 8

Hauling Costs for Minnesota pulpwood by road quality and truck size, all products (In dollars per cord-mile)

Road Class	Truck Size-mean load (cords)[1]			
	4	6	8	11
High speed, 45 m.p.h.	.115	.108	.111	.084
Class I, 35 m.p.h.	.168	.150	.155	.119
Class II, 25 m.p.h.	.239	.221	.226	.168
Class III, 16 m.p.h.	.336	.310	.332	.257
Class IV, 8 m.p.h.	.610	.593	.633	.487
Class V, 4 m.p.h.	1.106	1.018	1.194	.916
Fixed Costs (standby, delay,load,unload)	1.77	1.85	1.90	2.48

1 Truck description--all are equipped with loader; 4 cords, flat bed, 4 by 2, single axle, GVW 28,000 lbs.; 6 cords, flat bed, 6 by 4, tandem axle, GVW 37,000 lbs.; 8 cords, truck tractor, 4 by 2, single axle, with 28-30 ft. platform bed, GVW 59,000 lbs.; 10 cords, truck tractor, 4 x 6, tandem axle, with 30-35 ft. platform trailer, GVW 72,000 lbs.

Source: Handbook of Timber Appraisal, U.S.D.A. Forest Service Reg. 9, Chap. 260, June 1968, Amend. March, 1978.

Figure 9
Distribution of Species Within the Aspen Type
Mill Site: Virginia, MN Indludes Counties of Itasca, Lake and St. Louis

TYPE: ASPEN AREA = 1899000.0 ACRES ÷ NUMBER OF PLOTS 368 = 5160.33 ACRES PER PLOT

ITEM	DISTANCE TO MILL - MILES										
	0-15	16-30	31-45	46-60	61-75	76-90	91-105	106-120	121-135	136+	TOTALS
NUMBER OF PLOTS	7	36	57	88	86	48	22	17	6	1	368 ←
PERCENT OF TOTAL	1.902	9.783	15.489	23.913	23.370	13.043	5.978	4.620	1.630	.272	100.000
TYPE ACREAGE	36122.3	185771.7	294138.6	454108.7	443788.0	247695.7	113527.2	87725.5	30962.0	5160.3	1899000.0
CLASS MEAN TOTAL DISTANCE - MILES	11.0	24.1	38.0	53.2	67.6	81.1	96.7	112.9	126.0	135.6	
CLASS MEAN BY ROAD QUALITY											
1-PAVED	9.2	20.4	34.8	49.2	61.2	72.0	91.4	106.2	123.4	117.2	
2-GRAVELED	1.4	2.6	2.2	2.8	5.0	8.0	4.4	6.0	1.6	16.0	
3-ALL WEATHER	0	0	.0	.1	.1	.0	.0	.1	0	2.2	
4-DRY WEATHER	0	.0	.0	0	.2	0	.1	0	0	0	
5-WINTER ROADS	0	.0	.0	.1	.1	.0	0	0	0	0	
6-CROSS COUNTRY	.4	1.1	.9	1.0	1.0	1.0	.8	.7	1.0	.2	
TRANSPORT COST PER CORD - NOT WEIGHTED BY VOLUME											
OPTION 1 COST	3.533	5.805	7.178	9.060	10.895	12.537	13.963	15.730	17.352	18.684	
OPTION 2 COST	3.467	5.553	6.822	8.556	10.236	11.733	13.065	14.687	16.201	17.363	
OPTION 3 COST	3.643	5.909	7.212	9.036	10.795	12.356	13.737	15.409	17.049	18.124	
OPTION 4 COST	3.808	5.535	6.518	7.900	9.236	10.422	11.458	12.723	13.962	14.782	
SPECIE VOLUMES FOLLOWED BY VOLUME WEIGHTED TRANSPORT COSTS PER CORD											
JACK PINE VOL:	0	100626.4	8019.1	97401.2	120142.7	83122.5	0	0	0	0	409311.9
OPTION 1 COST	0	5.164	7.369	10.079	13.096	10.730	0	0	0	0	
OPTION 2 COST	0	4.963	7.016	9.490	12.225	10.106	0	0	0	0	
OPTION 3 COST	0	5.251	7.504	10.113	13.048	10.561	0	0	0	0	
OPTION 4 COST	0	5.033	6.752	8.736	10.975	9.037	0	0	0	0	
RED PINE VOL:	0	36973.7	22143.0	56417.8	73818.5	79804.4	37830.4	0	0	0	306987.8
OPTION 1 COST	0	4.995	7.323	11.969	11.293	11.991	12.996	0	0	0	
OPTION 2 COST	0	4.807	6.962	11.197	10.581	11.248	12.195	0	0	0	
OPTION 3 COST	0	5.075	7.312	12.127	11.121	11.833	12.756	0	0	0	
OPTION 4 COST	0	4.898	6.585	10.292	9.485	10.017	10.699	0	0	0	
WHITE PINE VOL:	0	49786.8	25502.3	107081.9	97019.3	16492.4	22127.5	0	0	0	318010.3
OPTION 1 COST	0	5.323	8.336	9.796	11.907	11.502	13.041	0	0	0	
OPTION 2 COST	0	5.117	7.888	9.209	11.139	10.809	12.236	0	0	0	
OPTION 3 COST	0	5.416	8.493	9.748	11.764	11.310	12.817	0	0	0	
OPTION 4 COST	0	5.155	7.506	8.451	9.991	9.609	10.748	0	0	0	
BALSAM VOL:	48796.0	274178.4	373643.7	491644.9	427290.5	293235.5	169439.3	123352.4	74009.4	0	2275590.3
OPTION 1 COST	3.607	5.044	7.286	9.173	10.522	12.497	14.162	15.396	17.817	0	
OPTION 2 COST	3.536	4.861	6.923	8.659	9.892	11.705	13.260	14.384	16.634	0	
OPTION 3 COST	3.724	5.134	7.323	9.146	10.405	12.335	14.006	15.084	17.578	0	
OPTION 4 COST	3.870	4.940	6.602	7.986	8.937	10.404	11.665	12.474	14.370	0	
WHITE SP. VOL:	3622.5	32850.6	33903.3	117051.7	129467.4	45204.5	50313.2	56010.2	0	0	468423.4
OPTION 1 COST	3.585	4.925	9.550	9.330	11.362	13.602	14.684	15.328	0	0	
OPTION 2 COST	3.517	4.753	8.996	8.756	10.664	12.652	13.733	14.315	0	0	
OPTION 3 COST	3.704	5.009	9.724	9.244	11.303	13.288	14.551	14.989	0	0	
OPTION 4 COST	3.855	4.843	8.451	8.075	9.631	11.149	12.086	12.402	0	0	

Figure 9 (cont.)

ASPEN

ITEM		DISTANCE TO MILL - MILES 0-15	16-30	31-45	46-60	61-75	76-90	91-105	106-120	121-135	136+	TOTALS
BLACK SP.	VOL:	6016.9	6378.2	44347.8	63745.5	107845.7	55308.4	17803.1	0	0	0	301445.6
OPTION 1	COST	3.669	5.566	6.754	8.990	11.732	13.967	16.782	0	0	0	0
OPTION 2	COST	3.592	5.336	6.434	8.493	10.982	12.992	15.640	0	0	0	0
OPTION 3	COST	3.782	5.668	6.780	8.971	11.646	13.710	16.751	0	0	0	0
OPTION 4	COST	3.914	5.350	6.187	7.849	9.899	11.474	13.786	0	0	0	0
N. WHT. CED.	VOL:	0	9660.1	3663.8	63172.7	18226.3	0	55189.7	0	0	0	149912.6
OPTION 1	COST	0	5.112	6.487	8.499	13.017	0	13.669	0	0	0	0
OPTION 2	COST	0	4.926	6.189	8.045	12.099	0	12.807	0	0	0	0
OPTION 3	COST	0	5.181	6.501	8.455	12.801	0	13.418	0	0	0	0
OPTION 4	COST	0	4.972	5.973	7.451	10.803	0	11.206	0	0	0	0
TAMARACK	VOL:	0	0	0	8958.3	39858.4	4628.8	4597.9	8215.2	7611.5	0	73870.1
OPTION 1	COST	0	0	0	8.586	12.356	11.643	13.985	16.228	17.271	0	0
OPTION 2	COST	0	0	0	8.129	11.592	10.943	13.092	16.945	16.125	0	0
OPTION 3	COST	0	0	0	8.561	12.395	11.448	13.702	17.970	16.941	0	0
OPTION 4	COST	0	0	0	7.532	10.462	9.709	11.422	14.702	13.879	0	0
OAK	VOL:	0	3405.8	2017.7	5026.2	7900.5	2977.5	0	9876.9	0	0	31204.5
OPTION 1	COST	0	5.065	7.456	9.377	9.933	11.325	0	14.977	0	0	0
OPTION 2	COST	0	4.884	7.099	8.850	9.361	10.646	0	14.020	0	0	0
OPTION 3	COST	0	5.199	7.462	9.356	9.784	11.155	0	14.655	0	0	0
OPTION 4	COST	0	4.992	6.702	8.142	8.454	9.494	0	12.135	0	0	0
ELM-ASH-COT.	VOL:	0	7988.2	59059.9	139901.6	187779.1	67497.1	81337.1	78220.2	10351.6	0	632134.8
OPTION 1	COST	0	4.682	6.553	8.714	10.069	13.400	13.427	15.606	17.470	0	0
OPTION 2	COST	0	4.519	6.251	8.238	9.489	12.480	12.589	14.586	16.316	0	0
OPTION 3	COST	0	4.750	6.589	8.671	9.948	13.115	13.207	15.301	17.226	0	0
OPTION 4	COST	0	4.649	6.041	7.618	8.581	11.013	11.046	12.635	14.100	0	0
MAPLE-BASS.	VOL:	0	2729.8	26457.0	74365.5	55762.5	36457.7	14552.1	5924.1	0	0	216248.6
OPTION 1	COST	0	5.887	6.964	9.067	10.245	12.476	13.397	14.977	0	0	0
OPTION 2	COST	0	5.630	6.630	8.562	9.648	11.644	12.566	14.020	0	0	0
OPTION 3	COST	0	5.975	6.968	9.050	10.148	12.211	13.160	14.655	0	0	0
OPTION 4	COST	0	5.584	6.327	7.910	8.742	10.319	11.006	12.135	0	0	0
→ ASPEN	VOL:	192557.6	1235702.0	1922427.9	3320948.5	3517066.7	1308529.7	870325.1	866434.2	226466.1	0	13460457.7 ←
OPTION 1	COST	3.645	5.421	7.314	9.041	11.095	12.751	13.798	15.451	17.219	0	0
OPTION 2	COST	3.570	5.203	6.948	8.535	10.416	11.915	12.923	14.437	16.084	0	0
OPTION 3	COST	3.759	5.496	7.361	9.012	11.015	12.532	13.589	15.127	16.936	0	0
OPTION 4	COST	3.897	5.216	6.633	7.883	9.407	10.559	11.342	12.505	13.876	0	0
BIRCH	VOL:	0	139550.7	384604.3	505113.4	480405.7	305321.0	245327.1	220175.6	0	0	2280497.7
OPTION 1	COST	0	5.177	7.315	8.994	10.788	12.443	13.405	17.767	0	0	0
OPTION 2	COST	0	4.980	6.947	8.503	10.133	11.654	12.561	16.482	0	0	0
OPTION 3	COST	0	5.267	7.342	8.988	10.665	12.279	13.174	17.366	0	0	0
OPTION 4	COST	0	5.042	6.617	7.865	9.136	10.361	11.024	14.246	0	0	0
BALSAM POP.	VOL:	0	23907.8	146305.6	540719.6	405679.0	224948.9	51061.4	107871.5	30239.5	0	1530733.3
OPTION 1	COST	0	5.751	7.470	10.270	10.455	12.578	13.856	15.754	18.418	0	0
OPTION 2	COST	0	5.502	7.089	9.676	9.840	11.760	12.984	14.717	17.189	0	0
OPTION 3	COST	0	5.789	7.481	10.345	10.373	12.336	13.690	15.465	18.218	0	0
OPTION 4	COST	0	5.438	6.722	8.903	8.911	10.405	11.422	12.765	14.862	0	0
VOLUME TOTAL		250993.1	1923738.6	3052095.5	5591548.7	5668262.1	2523528.5	1619903.8	1476080.3	348678.1	0	22,454,828.7

Figure 10

Distribution of Total Aspen Species by Cover Type for a Virginia, MN Millsite
Cook, Lake, and St. Louis Counties

ACCESS

SPECIES: ASPEN

ITEM	DISTANCE TO MILL - MILES										
	0-15	16-30	31-45	46-60	61-75	76-90	91-105	106-120	121-135	136+	TOTALS
TYPE VOLUMES											
PINE	0	102618.1	149068.5	58088.4	320712.9	138998.1	116577.7	0	0	0	886063.8
BALSAM	36654.7	125769.3	164392.8	35105.7	96267.6	48337.0	0	2867.5	22922.1	0	532316.7
SPRUCE	0	0	86458.5	17460.3	61790.7	22518.1	0	28664.9	0	0	216892.5
OTHER SFTWDS	0	0	0	25765.4	26753.5	26581.8	0	0	1976.2	0	81076.9
ASPEN	192557.6	1235702.0	1922427.9	3320948.5	3517066.7	1308529.7	870325.1	866434.2	226466.1	0	13460457.7
BIRCH	31484.2	109958.3	130255.9	139534.9	292891.4	414519.6	26331.0	23141.3	0	0	1168116.7
OTHER HDWDS	28698.2	21690.5	22569.2	108452.6	88515.1	64851.9	77252.0	13270.2	49411.0	0	474710.5
TOTAL VOLUME	289394.6	1595738.1	2475172.8	3705355.7	4403997.8	2024336.2	1090485.8	934378.2	300775.4	0	16,819,634.8

OVERALL-VOLUME WEIGHTED TRANSPORT COSTS: $/CORD

OPTION 1 COST	3.866	5.419	7.470	9.004	11.128	13.118	13.968	15.494	17.561	0
OPTION 2 COST	3.775	5.202	7.087	8.502	10.445	12.260	13.075	14.477	16.398	0
OPTION 3 COST	4.005	5.493	7.514	8.975	11.043	12.954	13.756	15.175	17.299	0
OPTION 4 COST	4.087	5.214	6.751	7.854	9.429	10.883	11.472	12.541	14.155	0

PERCENT OF GROWING STOCK:

	1.7	9.5	14.7	22.0	26.2	12.0	6.5	5.6	1.8	0	100.0

Figure 11 describes the cumulative and discrete distribution of softwoods and hardwoods relative to the Virginia Mill Site by distance class.

We also wanted to analyze demand for the timber resource within the Arrowhead Region. In our search for this information, we discovered the industries contacted were not comfortable with supplying ARDC with their utilization information. However, the industries were comfortable with providing this information to researchers at the NCFES. As a result, it was necessary to rely on staff at NCFES for information on the demand and utilization of timber resources within the Arrowhead Region.

(Figure 12, Arrowhead Region Average Saw Timber Stumpage Price, All Agencies; County State National Forest and Indian)
(Figure 13, Average Pulpwood Stumpage Price, All Agencies; County State National Forest and Indian)

By utilizing information provided by NCFES personnel, we were able to include in the report data on the pattern of stumpage price behavior within this time frame of 1965-1977. In terms of pulpwood production, the Arrowhead Region historically has provided a large share of pulpwood produced in the State of Minnesota. Utilizing information that has been collected by research staff at NCFES discovered that 74 per cent of all pulpwood produced in Minnesota in 1975 was obtained from counties in the Arrowhead Region. There was a 50 per cent increase in total timber harvested in 1975 as compared to 1960.

(Figure 14, 1975 Pulpwood Production in the Arrowhead Region by County)
(Figure 15, Arrowhead Region, Wood Harvested by County 1960-1976)

Current Work at ARDC that is reliant on NCFES Inventory Data and Research

At the present time, the ARDC is currently under contract to the U.S. Forest Service to evaluate wood energy within the Arrowhead Region. This study essentially involves an analysis of wood energy potential from non-merchantable species and wood residues on the federal ownership within the Superior National Forest and an analysis non-industrial private forest lands in the region regarding timber supply and wood energy. To accomplish the first aim of this research we are evaluating the use of the STEMS sub-routine of FREP (STEMS= Stand and Tree Evaluation Modeling System; FREP=Forest Resources Evaluation Program) that has been developed at the NCFES timber inventory data to develop estimates of energy potential from non-merchantable species on the National Forest ownership within the Superior National Forest. We will also be conducting an analysis of potential energy available from topwood and limbs remaining after commercial harvest on timber (using methods developed by the U.S. Forest Service North East Forest Experiment Station).

It should be evident through this discussion that by simple necessity, regional planning in forested areas of Minnesota is reliant on timber inventory information produced by the NCFES.

Comment on Continuing Concerns on Forestry Inventory Information and NCFES Research

The Forestry Advisory Committee of the ARDC has adopted a number of goal

Figure 11

Mill Site: Virginia; includes Cook, Lake and St. Louis Counties
Distribution of Growing Stock Volumes by Distance from Mill Site

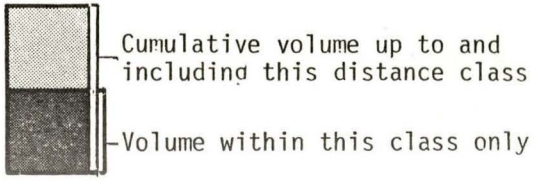
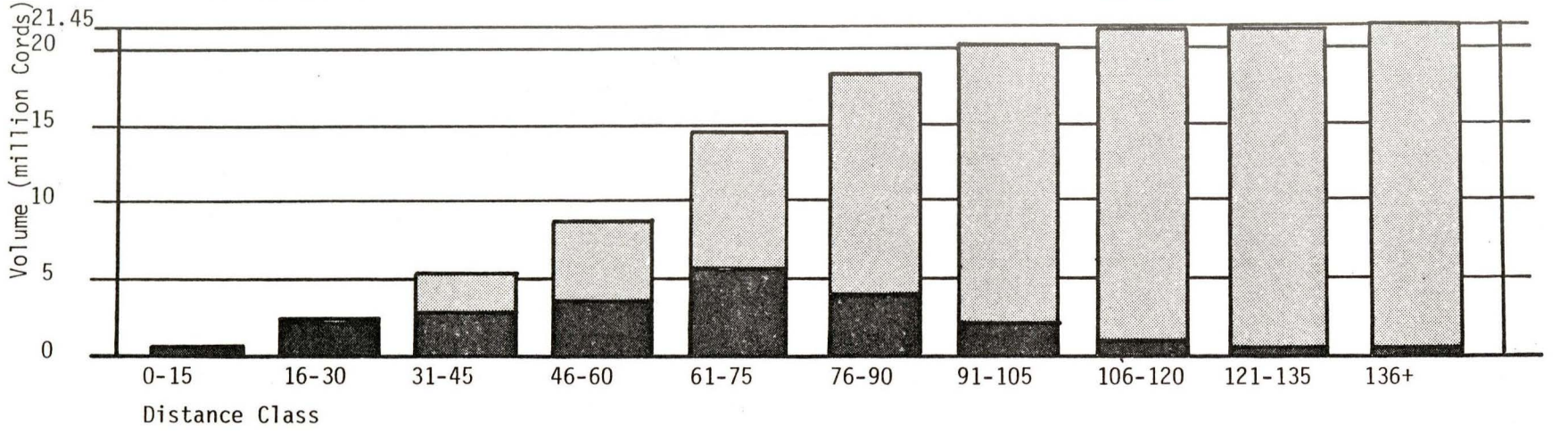


Figure 5a Total Softwoods



Total Hardwoods

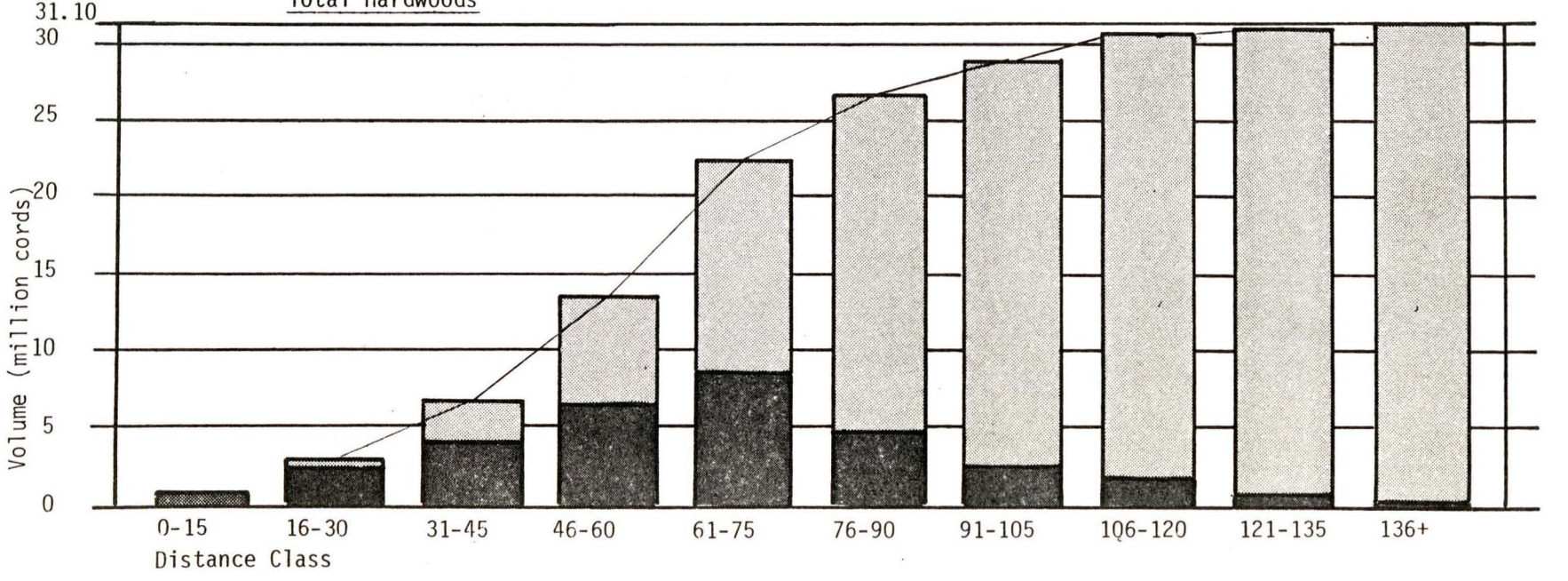


Figure 12

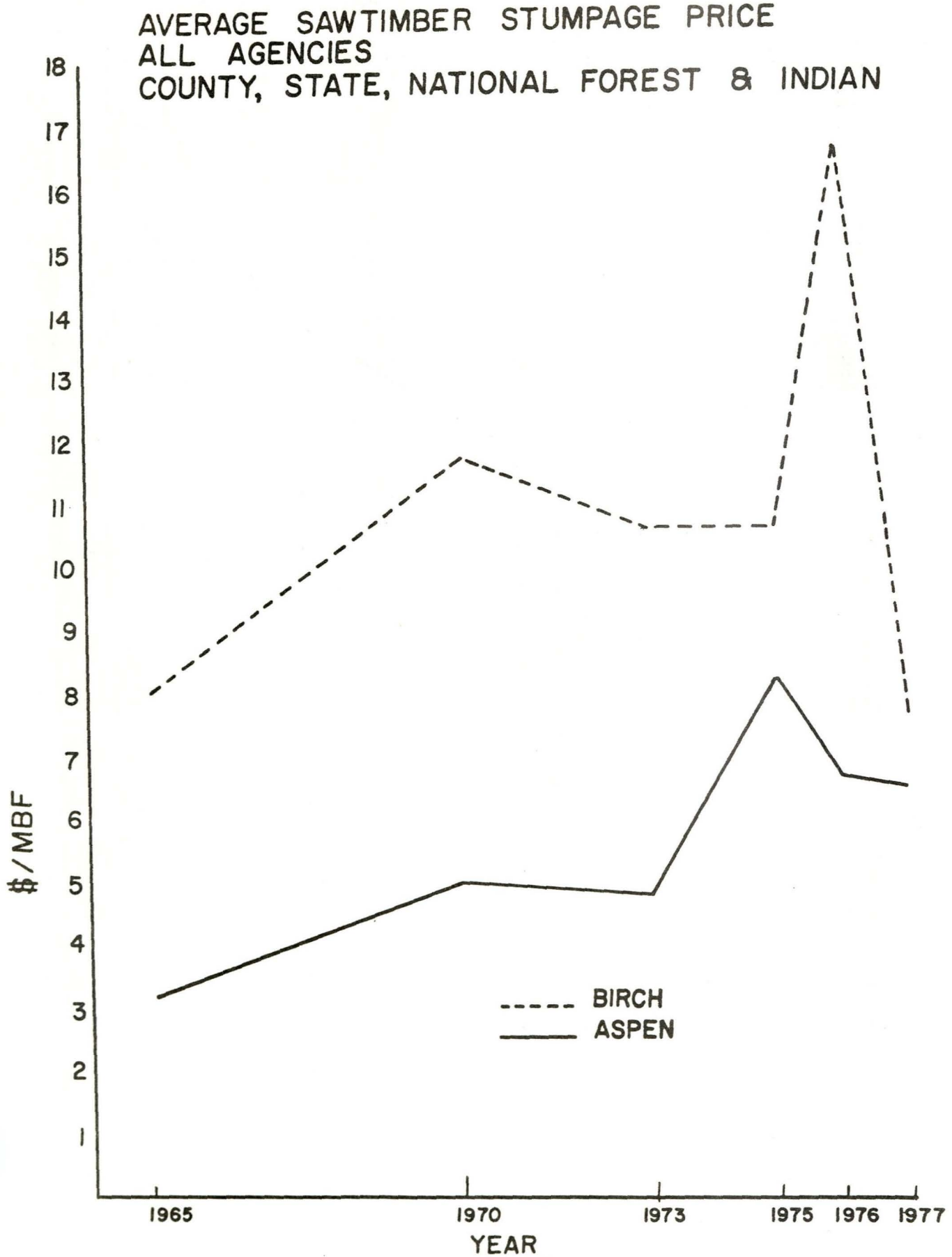

AVERAGE SAWTIMBER STUMPAGE PRICE
ALL AGENCIES
COUNTY, STATE, NATIONAL FOREST & INDIAN
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
$/MBF
BIRCH
ASPEN
1965
1970
1973
1975
1976
1977
YEAR

Figure 13

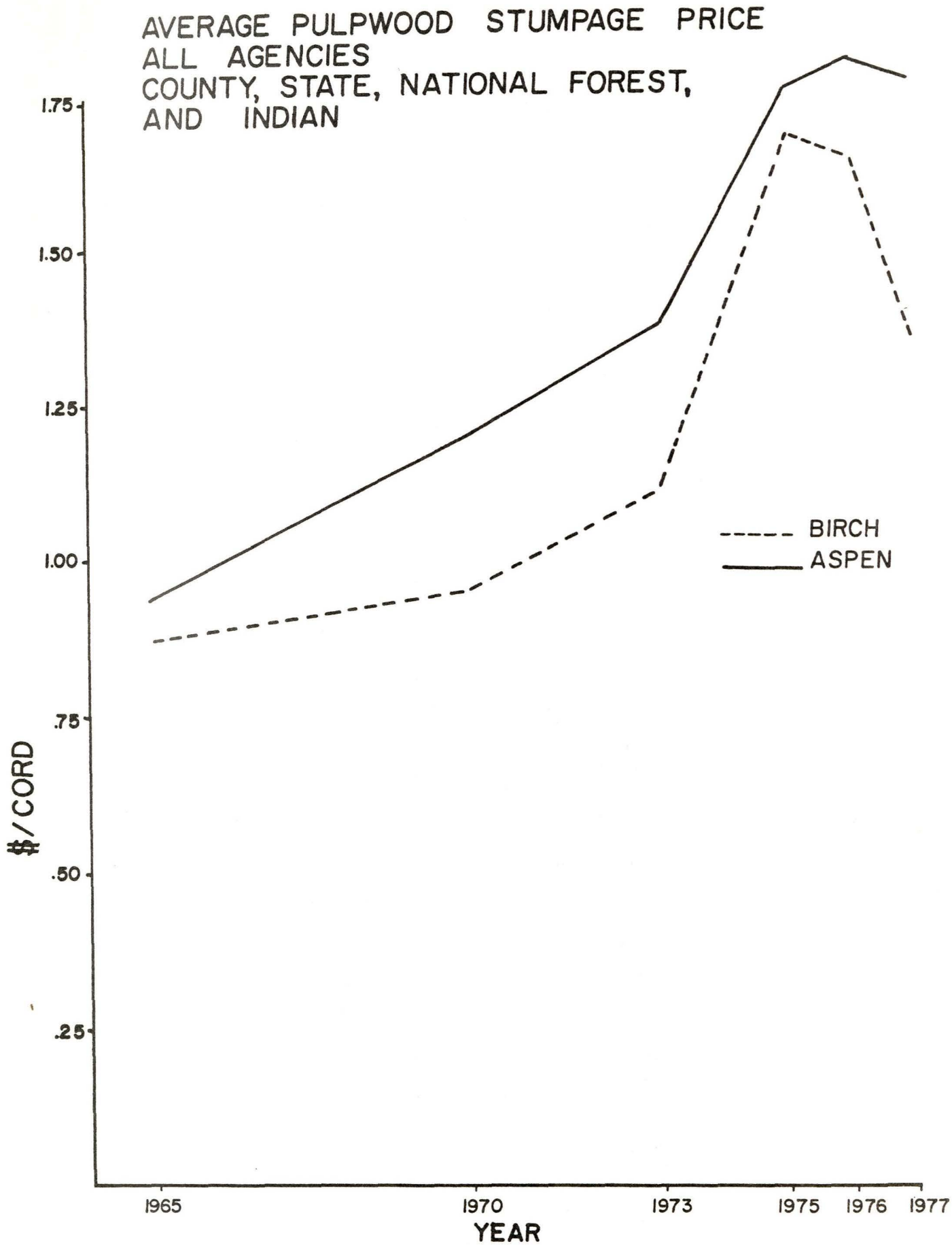

AVERAGE PULPWOOD STUMPAGE PRICE
ALL AGENCIES
COUNTY, STATE, NATIONAL FOREST,
AND INDIAN
1.75
1.50
1.25
1.00
.75
.50
.25
$/CORD
BIRCH
ASPEN
1965
1970
1973
1975
1976
1977
YEAR

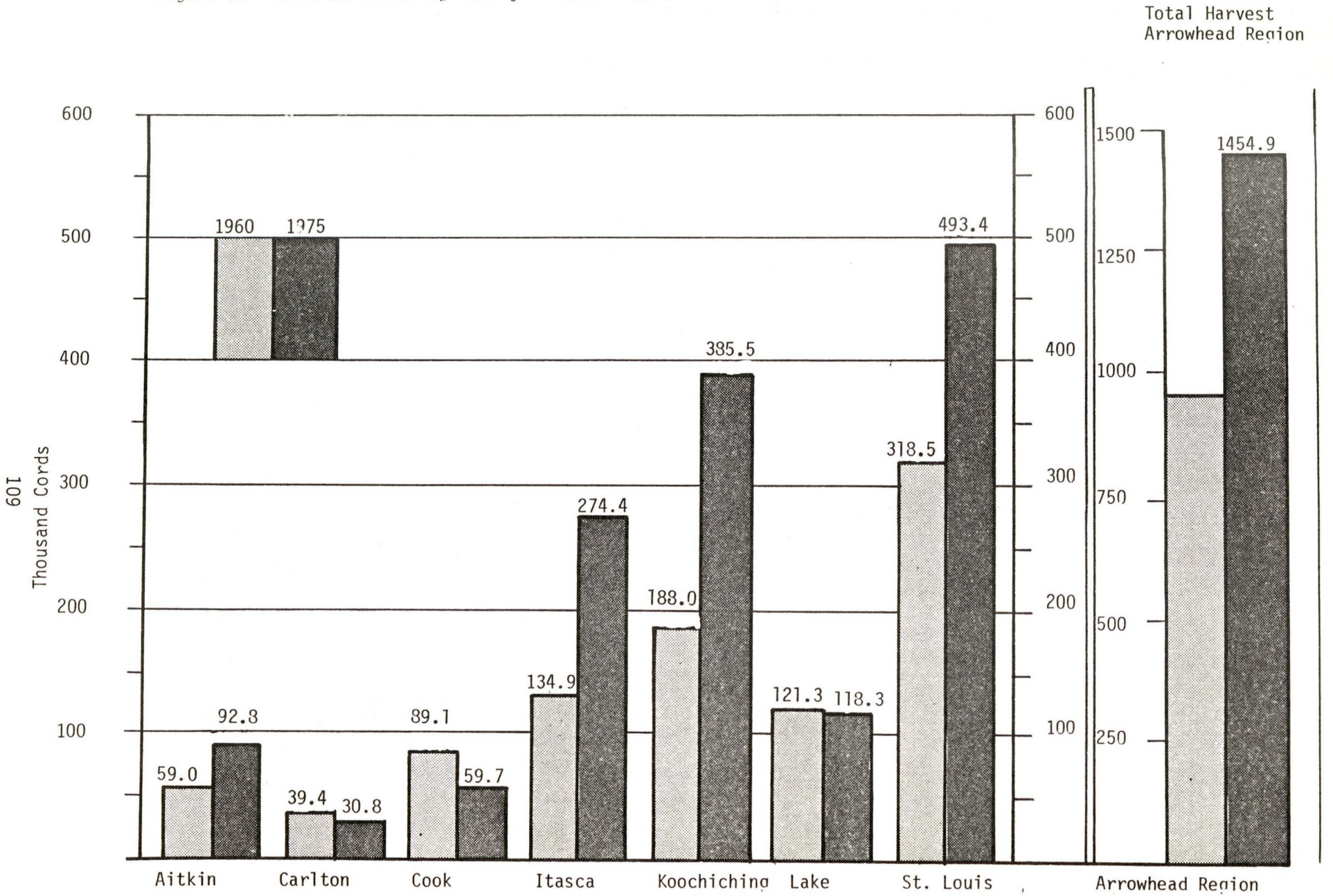
Figure 14

1975 PULPWOOD PRODUCTION IN THE ARROWHEAD REGION BY COUNTY

Source: U.S. Forest Service Resource Bulletin NC-34 (Blyth, Hahn)
(Cords)

	Aitkin	Carlton	Cook	Itasca	Koochi-ching	Lake	St. Louis	Reg. Total	State Total	Ratio: Region /State
Balsam Fir	662	524	1479	26057	39643	12009	22796	103170	121296	.8505
Jack Pine	1333	1938	3780	7399	12558	21052	64191	112251	180543	.6217
Red Pine	-	500	74	741	1823	950	3429	7517	10790	.6967
White Pine	-	-	-	742	2540	-	3688	6970	7386	.9437
Spruce	1468	262	8447	16055	75689	24670	43795	170386	202004	.8435
Tamarack	4113	259	-	5312	23458	68	6842	40052	56266	.7118
Aspen	34528	17338	15915	56522	126238	13420	184212	448173	615995	.7276
Balsam Poplar	-	-	-	220	6107	-	3701	10028	10725	.9350
White Birch	2515	3133	-	2614	2947	2036	7682	20927	35474	.5899
Yellow Birch and Other Hardwoods	-	-	-	-	-	-	-	-	5	-
Elm	-	-	-	-	692	-	-	692	733	.9441
Hard Maple	-	19	-	24	14	-	8	65	200	.3250
Soft Maple	-	8	-	5	17	-	35	65	79	.8228
Red Oak	5541	376	-	-	693	-	-	6610	9703	.6812
Total Cords	50160	24357	29695	115691	292419	74205	340379	926906	1251254	.7408

Figure 15 Wood Harvested by County - 1960 - 1976



Source: North Central Forest Experiment Station, St. Paul, Minnesota

statements that relate directly to forestry inventory and research. One of these goals states a need for "an integrated information system that determines and predicts needs and demands affecting area forests, and which provides adequate data for identifying and evaluating research management alternatives." A further refinement of this statement is a policy that "comprehensive, coordinated, and current information on the forest resources of the region should be available for all public and private interests." Another policy relates to the need to "better coordinate and provide the necessary funding and manpower necessary to collect, analyze, and interpret forest inventory data at more frequent intervals." Some operational concerns that the ARDC Forestry Committee expressed through the goal statements relate to improved useability of forest inventory data; "inventory data collected by all agencies should be standardized to permit data storage for affective retrevial; increase utilization of FREP or similar models to update forest research data between inventories; implement FREP or similar evaluation systems to predict the effect of management and harvesting schedules in future resources and availability."

A discussion of forest inventory with reference to regional planning for the economic and social welfare in the population of the Arrowhead Region follows. We feel there is a need to develop a consolidated information base that would include forest information as well as all of the other social, economic and demographic data that we need to plan for resource development on a regional basis.

From a geographic standpoint, we have been elated when NCFES research efforts have been done on a regional basis (i.e. consistent with Minnesota Region boundaries). A good example of past NCFES research efforts of this type is a 1978 study that analyzed the income generated in the primary forest industry in the Arrowhead Region (Myers, Kallio, and Friest, 1975). We feel that current NCFES proposals to update and expand the forestry sector on the input-output tables for the Arrowhead Region would be a significant improvement for our planning purposes. We also believe a NCFES proposal to develop a regional timber industry component for a business index for the Arrowhead Region has very positive potential for regional planning.

In summary, for regional planning purposes in Minnesota, we need accurate information on the forest resource in the state. From our experience at ARDC, we feel the NCFES is the best qualified and most appropriate agency to provide this resource data. As evidenced by the various testimonies presented before Congress prior to passage of the 1978 BWCA legislation, we must have accurate resource information to develop intelligent responses to various government and private programs that have the potential to affect the utilization and supply of the timber resource. We feel an expanded effort at maintaining current forest inventory information, such as that possible through the use of FREP, will assist regional planners in evaluating changing resource and economic conditions in forested areas in Minnesota. Finally, we feel there is a tremendous opportunity for increasing technology transfer of NCFES research and timber inventory information for greater public use and benefit.

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FUTURE RESOURCE INVENTORIES

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Two major events occurred recently that will profoundly affect all future resource inventories. The first and most visible of these occurrences was the passage in 1974 of the Resources Planning Act (PL93-378)(RPA). The net effect of RPA for the USDA Forest Service Resource Evaluation Units in the country is to expand their timber-oriented inventories to provide more complete multi-resource information. The second event was the double-digit inflation that has occurred in our economy and has severely eroded our productivity per dollar.

Alternate Data Sources

We will continue to rely on the active cooperation and participation by the States, universities, industries, consultants, environmental groups, and the many others that are concerned about our natural resources. The efforts of these organizations will continue to provide the input necessary for successful inventories. The continuation of the current economic situation will make every new resource inventory a difficult compromise at best. Our resource evaluation unit clearly sees the mandate of RPA as a need to improve methods of ensuring a fair analysis of our priorities in the future. We can no longer consider timber as the sole driving force of our resource inventories. At the same time we are forced to realize that we can only include so much in our inventories design.

However, we must seek alternate sources of resource information whenver possible and derive methods of extracting more information from existing resource data.

To fulfill our responsibility dictated by RPA, and remain within our limited budget, we will have to devise new ways to collect data. Following are some of the innovative ideas that we feel will make the greatest change in the way we will collect, compute, retrieve, and analyze resource inventory data in the future:

Bayesian Estimators - Bayesian Estimation is a statistical procedure that uses data from past and/or adjacent surveys to improve the precision and accuracy of inventory statistical estimates. Preliminary tests indicate that present levels of accuracy for county and unit volume estimates may be improved by 10 to 15 percent or more by using Bayesian procedures. Or, if present levels of accuracy are acceptable, these estimates could be derived by measuring 10 to 15 percent fewer plots. This research is being conducted cooperatively between the North Central Forest Experiment Station and the University of Minnesota and is headed by Dr. Alan Ek of the College of Forestry at the University.

Management Information Systems - We plan to create System 2000 data bases for all future resource inventories in our region. This system of data bases will allow researchers and analysts with limited computer programming knowledge access to the inventory data at low cost.

We are currently redesigning our data base structure to improve its efficiency and enhance regional resource analysis capabilities. With the addition of predefined table generating programs, many special requests in the future will be handled without the services of experienced programmers.

Computer Digitizing - We are testing a new computer digitizing system that determines the coordinates of our field plot locations to within 10 meters on United States Geological Survey quad maps and records these coordinates in the Universal Transverse Mercator (UTM) System. This process in conjunction with System 2000 and the Bayesian procedures could allow us to acquire precise statistics for local areas. For example, we could determine the available resource within 100 miles of Bemidji, Minnesota. This information in conjunction with plot data regarding stand operability, such as distance to road, slope, aspect, volume class, etc., should prove useful in analyzing how much of that resource is economically available. In another application, tie-in of UTM's with Landsat data could greatly improve image registration accuracy, which in turn could provide better land change information.

Graphics - Computer graphics is another area in which we feel we are making significant progress. To a researcher or analyst a picture can often be worth a thousand tables when it comes to assessing what's happening to the resource. We are striving to link graphics capabilities with System 2000 to provide greater flexibility in data retrievals for users, researchers, and analysts.

Land Change Analysis - The analysis of what's happening to the resource on the ground poses some perplexing problems for inventory designers. What happened, where did it happen, and most importantly how will we know that it happened? Landsat satellite imagery and low altitude photography are the major methods being researched in this area. To date our experiences with Landsat have not been encouraging but we are

convinced that with time and technology imagery will yield the land change information we need at low cost. Unfortunately the critical element of time dictates that we also investigate an alternative approach. The most promising one appears to be low-altitude 35mm photography. The basic premise of this research effort is that conventional photography is not well adapted due to limitations of resolution, contrast, and scale to meet the need for detailed information pertaining to detection of change. This becomes particularly critical when the date of the conventional photography is not reasonably close to the date of fieldwork. Low-altitude photography may be a time-and cost-efficient method to eliminate this problem.

An added bonus of the low-altitude photography may be the presence of easily obtained data relating to other nontimber resources. In any event, it appears that the ability to successfully detect change will greatly enhance the application of forest growth simulation in inventory design.

Forest Growth Simulation - The Forest Resources Evaluation Program (FREP) is the most exciting of all the new inventory enhancement techniques. We are currently working with the development team to incorporate the individual tree growth projection system (STEMS), part of this computerized modelling system, into our resource inventory design. Although several alternative sampling techniques have been discussed, the use of growth modeling seems to have the most appeal from an intuitive and practical standpoint. Growth modeling doesn't require complicated mathematical computations and by using individual tree simulation it retains the integrity of the original inventory tree list. This latter fact conveniently allows summarization of the inventory data in the traditional manner.

The basic concept of the growth model inventory design involves stratifying our sample into undisturbed and disturbed plots (therefore, accurate land change information is needed). All of the disturbed plots would be remeasured along with a subsample of the undisturbed plots. Undisturbed plots that were not remeasured would be updated by the projection system. The cost of updating a forest plot by projection is about 15 cents as compared to $250 for relocating and remeasuring a permanent sample plot on the ground. The total reduction in the number of field plots measured with such a design could add up to 30 percent or more.

All of the intricate details of incorportaing a projection system into our inventory design have not yet been worked out, but we have already begun to use parts of the growth projection process. To date we have planned or carried out seven resource inventory and analysis projects using modified versions of the FREP tree growth projection system. These projects reflect our belief that growth simulation will become an indispensible tool in future resource inventories. The following brief summaries of these projects indicate many of the potential uses we see for growth modeling:

(1) The 1969 Chippewa National Forest inventory data were updated with removals to 1977 so that they would coincide with the date of the plot work carried out in the remainder of the Northern Pine Survey Unit of Minnesota.

(2) Predicted timber yields were computed for northern Minnesota for the decade 1977-1986 using two selected sets of harvest criteria (Jakes and Smith 1980a). More work is planned in this area using the growth projection system to look at the long term effects on timber yields using different management strategies.

(3) Treatment opportunities in Minnesota were studied. (Jakes and Smith 1980b). Statewide needs for restocking and stand conversion were also analyzed. Much effort will be devoted to treatment opportunities during the coming years due to the increasing demands being made on our forest land. Of particular interest is the economic impact of restocking nonstocked and poorly stocked stands.

4) The 1968 Wisconsin survey was updated to the year 1979 without new photos or fieldwork (Raile and Smith, 1980). We feel these updated statistics are reasonable estimates of the current resource in Wisconsin. This type of updating between major resource inventories may be one of the more important uses of forest growth simulation.

5) An upper Lake States regional report will be produced using a modified version of the projection system. The main emphasis of this report will be on the resource situation in the heavily wooded northern portions of Minnesota, Wisconsin and Michigan.

6) The timber resource statistics for the Hiawatha National orest will be updated so that the eastern portion of Michigan's Upper Peninsula will be reported for a common point in time.

7) An integrated growth model inventory design is currently being tested for possible use in the fourth Wisconsin resource inventory. This new inventory design, if successful, could dramatically improve the timeliness of State and regional reporting of resource information as well as substantially reduce field inventory work and therefore the cost of the inventory.

Although much emphasis is being placed on the role of growth modeling in field inventory design, many of the previous examples demonstrate that its use as an analysis and planning tool will be equally important.

Nontimber Resources

The demand for nontimber--water, wildlife, and recreation--resource information seems to increase at an exponential rate and collection of such information will likely play a more important

role in future inventories. We have always collected some data about nontimber resources because all components of the forest are ecologically linked. Some minor expansions of existing data may provide a wealth of new information once we better understand the interrelations of forest ecosystms as they relate to resource analysis.

For example, in the last survey of Minnesota information on distance to water was collected. More specific information about whether the water is a lake, river, stream, pond, etc., and perhaps a size classification will be collected in the future. This added information, when coupled with the other forest and water data currently collected, may yield much information about the condition and extent of forest watersheds.

Demand for information about wildlife habitat is constantly increasing. In the current Michigan and North Dakota surveys we are collecting data on shrub and herbaceous species of plants. This information will help to better define wildlife habitat within our forests and where these habitats are located. A cooperative study is currently being conducted at the University of Minnesota in which an assessment of existing data as well as new data needs for defining habitat characteristics is being reviewed. One area of wildlife data collection in which we perceive a need for more research is in finding economical ways to measure interspersion and edge witnout drastically altering current inventory design. Low-altitude photography might provide this information.

With current energy shortages and the high cost of gasoline, more emphasis has been placed on the recreational potential of local forested areas. In the last Minnesota survey we collected information on distance to road and the general slope, aspect, and position of each forest sample plot. If we know that cross country skiers enjoy skiing through 35-year-old aspen forests containing gentle slopes, we could produce information on how much of that type of forest we have and approximately where it is located.

In many areas of nontimber resources the research necessary to associate animal or human behavioral patterns to physical attributes of the forest is the limiting factor in multiresource analysis. If we know what consumers or users of the forest resource want, we can tell them if we have it, how much we have, and where it is. In all future inventories, we see a clear need to define data in a multiresource rather than a functional framework. We are not resource managers, but we are mandated to provide useful multiresource management information. We need user assistance in determining what is useful management information.

SUMMARY

I have only glossed over some of what we think will significantly affect future resource inventories. Problems in the future will be numerous, and they may not be easily solved. We are embarking upon a

new era in resource inventories with a great deal of new technology as well as optimism. Field data collected in the future will be more multiresource oriented, with more emphasis placed on remotely sensed data, data from other sources, and synthesized data such as that produced by growth simulation. The days of the field inventory are not over, but the economics and technology of the future must shift a greater share of the resource inventory burden to new and more sophisticated techniques.

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CONFERENCE WRAP-UP

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University of Minnesota

Forest survey has a long tradition of importance in this country as a basis for forest policy and planning. Several factors contribute to this being even more so today. As competition for our forest resources has intensified between uses and within uses, their values have become more evident. As a result, planning and the making of decisions regarding use and management of these resources have become more dependent on the availability and timeliness of good information. Mandated national and state level assessments of forest resources also add new dimensions to information needs. We see an increase in the array of interests desiring use of the forest. This results in the need for information of diverse forms and with high degrees of precision not previously required. All of these factors have contributed to increased demands for inventory information.

The professional forestry community in Minnesota and those with a vested interest in the actions of that community are represented at these conferences this week. It is beneficial to have the kind of open discussion and presentations on the Minnesota Forest Resource Inventory that have been evident today. They provide an opportunity for both an improved understanding by the users of this inventory information and as a means to communicate users concerns and needs to those responsible for the planning, conduct and reporting of such inventories.

During these conferences, we have heard an overview of forest inventory responsibilities authorized by Congress and carried out by the Forest Service. This explanation helped us put Minnesota in perspective relative to the national and regional purposes such inventories serve. We were informed that the goal of a 10-year inventory cycle has not yet been achieved largely because of funding limitations.

A report on the Lake States forest resource trends was presented. With 38% of the area of the three states classified as commercial forest land, the similarities in forest types and conditions across Michigan, Wisconsin, and Minnesota are important to the common populations these forests serve and to the common markets they presently and potentially impact. The 25% state, county, and municipal forest land ownership across this region is unique and provides a basis for more locally determined options for the forest resource than exists elsewhere.

We next turned to the Minnesota inventory itself and heard of the procedures used in the conduct of this inventory. Field sampling involved 8,547 ground plots measured between 1974 and 1978. State funding provided for a tripling of sampling intensity resulting in improved precision for estimates. The Minnesota timber utilization results for 1977 and the changes that have occurred in forest resource data resulting from this 1977 inventory were examined. Some highlights of these findings are as follows:

- An 11% decline in commercial forest land acreage from 1962 to 1977 resulted from a 1.7 million acre loss primarily from reservation for recreational use, urban encroachment, and conversion to agricultural use.

- Growing-stock volume showed a 21% increase over this same period.

The balance of the program was devoted to a discussion by representatives of the various users groups regarding the needs the inventory data can and should fulfill from their viewpoint. Identified as important needs the inventory should meet were:

- Data for planning by public bodies in regional analyses, land use and statewide resource assessments.

- Data base for the private sector for orderly planning of operations as well as for the development of strategic long range plans.

- Use in research in helping to interpret inventory in applications to a wide array of problems.

- As a basis for analyzing and interpreting resource conflict issues and management options in seeking solutions that are environmentally sound.

- To measure progress in a forest system toward policy or management goals.

Users emphasized the importance of timeliness in reporting inventory data and in being able to obtain access to the data base for special analyses.

Finally, a brief period was devoted to the issue of future forest resource inventories and changes that may be likely in their conduct. Among developments under consideration are the application of Bayesian estimators, land use change analysis, management information systems, and forest growth simulation. The integration of other resource data needs was also noted as an imperative.

This then leads me to some general observations resulting from the presentations and discussions here and from experiences as a user and observer of inventory information over time. First, the statewide forest resource inventories to which we are addressing ourselves are not and should not be considered as the source for all of our inventory data needs in forestry. The basic purpose of the statewide inventory is to provide information useful at a broad-based policy and program assessment level. This is essential to fulfilling the Congressional mandates as set forth in the legislation of 1928, 1974, and 1978. Accordingly, the statewide inventory data is not site-specific. That is, it does not provide site-specific answers for resource management decisions. In addition, the inventory fundamentally provides biological and physical resource information. Only in a very broad sense do economic criteria enter into the definitions that form the basis for what is measured and reported. As a result, other approaches are needed or special analyses must be made to provide location and economic oriented answers.

Second, there are diverse views on the scope, intensity, timing, and design needs for statewide forest inventories. Inventory data can be helpful to those who must make decisions regarding our forest resources. The issues and objectives for which inventory data are necessary to guide decisions in the public and private sectors vary. Thus, to some extent the inventory designs, techniques, standards, and definitions will vary in seeking to achieve efficiency for any one of the different needs. A statewide forest inventory such as we have been discussing can be only a compromise when designed to simultaneously serve several different sets of users. As a result, some users' expectations may significantly exceed what is deliverable or what is mandated as the principal focus of future inventories.

Third, it is still troubling to me that definitions and standards used to define measurements often play a subtle but significant role in impacting findings of a statewide inventory. Inclusion or exclusion for measurement in the inventory is automatic once such dimensions are established. Fourth, care in interpretation and analysis of inventory data is an important responsibility of anyone who makes public use of these data. Limitations of the data and the sampling precision for estimates sometimes are either overlooked or not understood. Fifth, efforts need to be directed more intensively toward incorporating other forest resource aspects into the inventory process. Finally, as important as today's discussion has been in informing those in attendance of the recent Minnesota forest inventory methods and results, we need to give additional effort to effectively reach the media and the broader publics who should have a better understanding of this information and the issues it addresses. Timely communication is a key unresolved need.

In summary, there have been significant advances in statistical and inventorying techniques. We are all conscious of the need for more efficient means of achieving our data needs for both policy and program assessment and for resource planning and management purposes. Adapting new methods and concepts which have been proven to statewide inventories seems to be an essential consideration in achieving such ends. Reviewing the roles and relationships between federal, state, and local governmental units and between the private sector to ensure that a planned and coordinated inventory effort on a statewide basis supplements and complements existing and ongoing inventory efforts by individual forest resource owners and organizations is another avenue for such gains. As inventory needs increase for uses and forest resources other than timber, added responsibilities and complexities will be assumed by the inventory process.

It is not too early for us to be thinking of the fifth statewide forest resource inventory in Minnesota, even while the fourth inventory is still not finalized. An adequate, comprehensive, cost effective, and acceptable forest inventory, while elusive, is the goal we can and should continue to seek. These conferences serve a useful end toward that purpose when appropriate follow-up is taken based on the presentations and discussions.

U.S. Department of Agriculture, Forest Service.
1981. Proceedings of 1980 Minnesota Forest Resource Inventory Conferences. U.S. Department of Agriculture Forest Service, General Technical Report NC-64, 121 p. U.S. Department of Agriculture Forest Service, North Central Forest Experiment Station, St. Paul, Minnesota.

Contains 16 papers presented at the 1980 Minnesota Forest Resource Inventory Conferences.

KEY WORDS: sampling plan, techniques, Lake States, timber output, volume, growth, data utilization.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1981-766-658/158 REG.#6